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TP8709E
SEARCH AND RESCUE
DETECTION EXPERIMENT
PHASE I INITIAL PREPARATORY WORK

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JUNE, 1987

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Un sommaire en français de ce rapport est inclus avant la Table des Matières.

Transport Canada / Transports Canada

Development / Developpement

REPORT DOCUMENTATION FORM

1. Transport Canada Report No.	2. TDC Project No.	3. Recipient's Catalogue No.
TP 8709 E	6844	

4. Title and Subtitle	5. Report Date
Search and Rescue Experiment, Phase I Preparatory Work	June 1987
	6. Performing Organization Report No. 275-86G
7. Author(s)	8. Transport Canada File No.
B.R. Dawe, D. Finlayson and D. Bryant	D1460-220-5
9. Performing Organization Name and Address	10. DSS File No.
NORDCO Limited P.O. Box 8833 St. John's, Newfoundland A1B 3T2	11SD.T8200-6-6553-A
	11. DSS or Transport Canada Contract No. T8200-6-6553/01-SD
12. Sponsoring Agency Name and Address	13. Type of Report and Period Covered
Transportation Development Centre (TDC) 200 Dorchester Blvd. West Suite 601, West Tower Montreal, Quebec H2Z 1X4	Final, Feb. 87-June 87
	14. Sponsoring Agency Code
15. Supplementary Notes	16. TDC Project Officer C.A. Versailles

17. Abstract A four-phase project was developed in order to undertake an offshore ship-based search and rescue experiment and to conduct related experiments using a radar simulator. Phase I involved obtaining the information required to plan the experiment. The objectives of Phase I were to: specify the radar and infrared systems; identify the navigation system; identify the degree and type of United States Coast Guard (USCG) participation; designate the Canadian Coast Guard (CCG) ship, the location, and the time frame; and assess the Transport Canada (TC) marine radar simulators at Sydney and Cornwall for use in various search and rescue experiments. The Raytheon Marine Company Pathfinder ST Radar and the Sperry Corporation (RASCAR radars were found to have sufficient signal processing capability to make them suitable for the experiment. The system to be utilized will depend on availability. SPAR Aerospace Limited and Texas Instruments Limited (TI) were contacted regarding an infrared imaging system. The TI system was the preferred system as it is designed for shipboard use. However, as a result of a small test and communications with USCG personnel, who had experience with the TI system, it was concluded that currently available infrared systems are unsuitable for ship-based SAR operations and should not be tested in the planned experiment. A differential LORAN-C navigation system utilizing a moored LORAN-C buoy was found to be the most cost-effective system which meets the accuracy requirements of the experiment. The USCG will provide the LORAN-C buoy system and will place representatives on board the ship. The ship to be used will be the CCGS "Sir William Alexander", with the Canso Bank on the Scotian Shelf selected as the location. The planned start date for the experiment is September 15, 1988. The TC marine radar simulators were found to be unsuitable for simulating radar detection experiments but were found to be adequate for testing certain human factors related to search. All the objectives of the project were achieved.

18. Key Words	19. Distribution Statement
Search and Rescue, Radar, Infrared, Navigation, Simulators	Limited numberof copies available from Transportation Development Centre on request.

20. Security Classification (of this report)	21. Security Classification (of this page)	22. No. of Pages	23. Price
unclassified	unclassified	20	-

TDC CDT 79-005
Rev 86

Canada

Transports Canada / Transport Canada

Développement / Development

FORMULE DOCUMENTAIRE DU RAPPORT

1. N° du rapport Transports Canada	2. N° de l'étude — CDT	3. N° de catalogue du destinataire
TP8709	6844	

4. Titre et sous-titre	5. Date du rapport
Search and Rescue Detection Experiment, Phase I Preparatory Work	juin 1987
	6. N° du rapport de l'organisme exécutant: 275-86G
7. Auteur(s): B.R. Dawe, D. Finlayson and D. Bryant	8. N° de dossier Transports Canada: D1460-220-5
9. Nom et adresse de l'organisme exécutant: NORDCO Limited, P.O. Box 8833, St. John's, Newfoundland A1B 3T2	10. N° de dossier — ASC
	11. N° de contrat — ASC ou Transports Canada: T8200-6-6553/01-SD
12. Nom et adresse de l'organisme parrain: Centre de développement des transports (CDT), 200 ouest boul. Dorchester, Suite 601, tour, ouest, Montreal, Quebec H2Z 1X4	13. Genre de rapport et période visée: final, fév. 87 - juin 87
	14. Code de l'organisme parrain
15. Remarques additionnelles	16. Agent de projet — CDT: C.A. Versailles

17. Résumé

Ce rapport traite de l'élaboration d'un projet en quatre phases concernant l'expérimentation à bord d'un navire d'opérations de recherche et de sauvetage en mer, ainsi que la simulation des opérations radar connexes. Le but fixé à la phase I du projet a été de recueillir l'information nécessaire à la planification détaillée de l'expérimentation, à savoir: choisir les systèmes radar et infrarouges; choisir le système de navigation; déterminer la nature et le degré de participation de la Garde côtière des Etats-Unis; désigner le navire de la Garde côtière canadienne à mobiliser; déterminer l'emplacement et le calendrier de l'expérimentation et, enfin, évaluer les simulateurs radar se trouvant à Sydney et à Cornwall. Il a été déterminé que les systèmes radar Pathfinder/ST et RASCAR, de la Raytheon Marine Company et de la Sperry Corporation, respectivement, ont des fonctions de traitement des signaux suffisamment avancées pour convenir à l'expérimentation. Pour les systèmes de détection à infrarouge, les entreprises contactées ont été la SPAR Aerospace Limited et la Texas Instruments Limited (TI). Toutefois, à l'issue d'un petit essai et de conversations avec la Garde côtière des Etats-Unis, il a été décidé qu'aucun de ces deux systèmes infrarouges ne convenait à l'application envisagée et que leur expérimentation ne devrait pas avoir lieu. Côté système de navigation, le système LORAN-C en mode différentiel, complété d'une bouée LORAN-C amarrée, constitue le système le plus économique au regard du degré de précision nécessaire pour les fins de l'expérimentation envisagée. L'expérimentation aura lieu à bord du "Sir William Alexander" de la Garde côtière canadienne et se déroulera au Banc de Canso de la plate-forme Scotia. La date prévue de l'expérimentation est le 15 septembre 1988. Tous les objectifs fixés à la phase I du projet ont été atteints.

18. Mots-clés	19. Diffusion
Recherche et sauvetage, radar, infrarouge, navigation, simulateurs	Le Centre de développement des transports dispose d'un nombre limité d'exemplaires.

20. Classification de sécurité (de ce rapport)	21. Classification de sécurité (de cette page)	22. Nombre de pages	23. Prix
non-classifié	non-classifiée	20	-

CDT/TDC 79-005 Rev 86

Canada

EXECUTIVE SUMMARY

This document constitutes the final report on Phase I of a four phase project involving an experiment to test new shipborne radars (with advanced signal processing), infrared systems, and visual detection for their utility in search and rescue target detection under typical Canadian East Coast offshore conditions.

Phase I of the project had the following objectives:

1. Specify the radar and infrared systems to be used in the experiment;
2. Identify the navigation system to be used in the experiment;
3. Identify the degree and type of United States Coast Guard (USCG) participation in the experiment;
4. Designate the Canadian Coast Guard (CCG) ship to be used, the experiment location, and the time frame for the experiment.
5. Assess the Transport Canada marine radar simulators at Sydney and Cornwall for use in various search and rescue experiments.

All the major marine radar manufacturing companies were contacted. Two radar systems were selected for possible use in the experiment. These were the Raytheon Marine Company Pathfinder ST Radar and the Sperry Corporation RASCAR Radar. Both systems are new, have advanced signal processing capability, and use rasterscan displays. While each system has certain advantages and disadvantages, the Raytheon system is expected to be used because, in part, of the unavailability of the Sperry unit.

Two companies were located and contacted regarding infrared systems. They were Spar Aerospace Limited and Texas Instruments Incorporated. Both companies manufacture a military grade infrared system. The electro-optical specifications of both systems are essentially identical. Texas Instruments has a man portable system designed for installation on a ship. The unit is equipped with a special 2-axis pivot mount and yoke assembly providing operating stability onboard a vessel. Spar was only able to demonstrate a land based version (unit mounted on a tripod). Given this, the infrared system manufactured by Texas Instruments was preferred.

To finalize the evaluation of the infrared system, a NORDCO representative visited the USCG Research & Development Center, Groton, Connecticut, where discussions were held with their electro-optical specialist and a small shore-based test was undertaken using the Texas Instruments infrared system. Reports were also reviewed on ship-based performance tests. It was concluded that it would not be worthwhile to test either of the available infrared systems primarily because of potential stabilization problems and because of the narrow field of view in the current models.

After an extensive investigation of navigation systems it was concluded that a custom designed, LORAN-C differential navigation system would be the most suitable system to provide the required position information. The system would make use of a moored LORAN-C buoy for differential correction. Its accuracy, which is approximately 100 metres or less 95% of the time, and reliability would be sufficient for the experiment. Additionally, the system could be implemented within the budgetary constraints of the project.

The USCG agreed to participate in the experiment through the provision of equipment and the placement of representatives on board the ship during the experiment. Two LORAN-C buoys and the associated receiver equipment will be provided along with special passive radar reflectors.

The CCGS "Sir William Alexander", operating out of the Maritime Region, was designated for the experiment since it had the required mooring handling facilities and additional accommodation requirements for the extra crew and scientific personnel. During the experiment, the ship would be on search and rescue (SAR) and pollution patrol.

The Canso Bank on the Scotian Shelf was selected as the location for the experiment since it has the attributes of good LORAN-C coverage, little fishing activity during the fall months, and relatively little other marine traffic. The planned start date for the experiment was tentatively scheduled for September 15, 1987, subject to availability of the vessel and the radar system.

The radar simulators at the CCG College, Sydney, Nova Scotia, and the Transport Canada Training Institute at Cornwall, Ontario, were investigated for two reasons: first, to determine whether they could be used to simulate realistic marine radar search experiments; and second, to determine whether it would be possible to investigate human factors related to electronic searches using a standard marine radar. Neither facility was capable of simulating realistic targets and sea clutter representation sufficiently accurately to conduct SAR experiments. It was, however, concluded that human factor experiments could be undertaken.

In conclusion, all the objectives of Phase I have been met. Enough information has been gathered to proceed with the detailed planning of the experiment.

SOMMAIRE

Ce document constitue le rapport final de la phase I d'un projet en quatre phases concernant l'expérimentation de divers systèmes de détection: radars de bord à traitement de signal avancé, systèmes à infrarouge et détection visuelle visant à évaluer l'aptitude de chacun en service de recherche et de sauvetage au large de la côte Est du Canada, dans des conditions propres à cet environnement marin.

Les objectifs fixés à la phase I avaient été les suivants:

1. Choisir les systèmes radar et infrarouge à expérimenter.

2. Choisir le système de navigation.

3. Déterminer la nature et le degré de participation de la Garde côtière des Etats-Unis.

4. Désigner le navire de la Garde côtière canadienne à mobiliser et déterminer l'emplacement et le calendrier de l'expérimentation.

5. Evaluer les simulateurs radar de Transports Canada à Sydney et à Cornwall sur le plan de leur aptitude dans le domaine des opérations de recherche et de sauvetage en mer.

Tous les principaux fabricants de matériel radar à usages maritimes ont été contactés. Deux systèmes ont été pré-selectionnés en vue de l'expérimentation: le radar Pathfinder/ST de la Raytheon Marine Company et le RASCAR de la Sperry Corporation. Tous deux, de technologie nouvelle, font appel à un procédé avancé de traitement des signaux et utilisent des visuels à balayage ligne par ligne. Chacun, présente des avantages et des inconvénients; toutefois, c'est le système Raytheon qui sera probablement choisi, en partie à cause que celui de Sperry ne sera pas disponible.

Pour ce qui est des systèmes de détection à infrarouge, deux entreprises ont été sélectionnées et contactées: la Spar Aerospace Limited et la Texas Instruments Incorporated; toutes deux fabriquent des systèmes infrarouges à usages militaires. Les caractéristiques opto-électroniques des deux systèmes choisis sont pratiquement identiques. L'appareil fabriqué par Texas Instruments est portable et peut servir à bord d'un navire, grâce à un montage particulier à deux axes assurant sa stabilité à bord. Pour sa part, la Spar Aerospace n'avait qu'une version terrestre de son appareil, monté sur trépied. Pour cette raison, le système de la Texas Instruments a été choisi de préférence à celui de la Spar Aerospace.

Dans le but de compléter l'évaluation du système infrarouge retenu, un représentant de NORDCO s'est rendu au centre de recherche et de dévelopement de la Garde côtière des Etats-Unis, à Groton, dans le Connecticut; il y a rencontré le spécialiste an équipements opto-électroniques et soumis et le systéme de la Texas Instruments à un petit essai au sol. Il a également pris connaissance de rapports sur les performances de ce système à bord d'un navire. Finalement, aucun des deux systèmes n'a été utilisé; d'abord, à cause des problèmes d'instabilité notés et, ensuite, à cause du champ de vision étroit des modèles actuels.

Quant au choix du système de navigation, il s'est arrêté sur un système Loran-C étudié exprès, étant donné que ce dernier est le plus approprié à l'application envisagée. Une bouée Loran-C amarrée complétera le système en vue de corriger les différences de temps. La précision du système choisi (une centaine de mètres ou moins dans 95 p. 100 des cas) et sa fiabilité ont été jugés suffisants pour l'application envisagée, d'autant plus qu'il permet de respecter les contraintes budgétaires fixées.

La Garde côtière des Etats-Unis a accepté de fournir l'équipement voulu et des spécialistes à bord pour la durée des essais. Elle a également décidé de fournir deux bouées Loran-C ainsi que les récepteurs et les réflecteurs radar passifs nécessaires.

Le navire choisi est le Sir William Alexander de la Garde côtière canadienne, région des Maritimes, étant donné qu'il est équipé d'engins de mouillage et d'amarrage et qu'il possède l'espace voulu pour recevoir un équipage supplémentaire ainsi que le personnel scientifique. Lors de l'expérimentation, ce navire se trouvera en service de recherche et sauvetage et de repérage des sources de pollution.

Le lieu choisi pour l'expérimentation est le Banc de Canso de la plateforme Scotian car il présente les particularités suivantes: bonnes caractéristiques du point de vue de la couverture radioélectrique du système Loran-C, faible niveau des opérations de pêche durant les mois d'automne, trafic maritime relativement faible. Le début de l'expérimentation est prévu, en principe, pour le 15 septembre 1988, sous réserve de la mise à disposition du navire et du système radar.

Le simulateur radar se trouvant au CCG College de Sydney, Nouvelle-Ecosse, et celui de l'Institut de formation, Transports Canada, à Cornwall en Ontario ont été évalués; d'une part, pour déterminer leur aptitude à simuler fidélement des opérations de recherche à l'aide d'un radar de bord et, d'autre part, pour savoir dans quelle mesure ils pourraient servir à déterminer les facteurs ergonomiques en jeu lors des opérations de recherche en mer à l'aide d'appareils électroniques comme le radar de bord. Aucun des deux simulateurs n'a réussi à simuler des objets flottants et le clutter de mer avec suffisamment de fidélité pour être utile à la simulation d'opérations de recherche et de sauvetage. Par contre, ils se prêtaient aux expérimentations sur les facteurs ergonomiques.

En définitive, tous les objectifs de la phase I ont été atteints; de plus, une information suffisante a été recueillie ce qui permet de procéder à une planification détaillée de l'expérimentation envisagée.

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1.0 INTRODUCTION

This is the final report on Phase I of a four-phase project involving an experiment to test shipborne radar and infrared systems for their utility in search and rescue target detection. The project is being done under contract to the Transportation Development Centre (TDC), with considerable technical and logistical support provided by the Canadian Coast Guard (CCG).

The purpose of this phase was to identify the ship and time frame for the experiment, to source the sensor equipment, to identify the navigation system to be used, to clarify United States Coast Guard (USCG) participation in the experiment, and to determine whether CCG radar simulators might be of any use in search and rescue radar target detection studies. In addition, the results of Phase I were to be used to identify and define precisely the tasks required for Phase II, the detailed experiment planning phase.

The following sections describe the objectives of Phase I in detail, provide details of the results of the work undertaken, provide conclusions, and outline recommendations based on the results.

2.0 OBJECTIVES

The objectives are described in the following subsections:

2.1 Investigation of Sensor Systems

The objective here was to identify and locate sources for an infrared system and a sophisticated marine radar signal processing unit (or a complete radar system), to evaluate the systems, and to make arrangements for the utilization of the selected systems in the actual experiments.

2.2 USCG Participation

In order to maximize the benefits of any search and rescue experiment it is important that the experiment methodology utilized to be consistent with that developed by the USCG. Any data collected will then be compatible with the very substantial data base already compiled by the USCG and will benefit the international community. Access to certain equipment and knowledge of techniques employed by the USCG will help minimize the costs and the risks involved. The object here then is to determine the degree and type of USCG participation in the experiment and to formalize the arrangement.

2.3 Identification of a Navigation System

An accurate and reliable navigation system is crucial to this type of experiment. The task here was to investigate various systems and to subsequently identify a system or a combination of systems suitable for the experiment. The cost of the system was to be kept at a minimum.

2.4 Designation of Ship, Location, and Time Frame for Experiment

This type of experiment requires the use of a trained CCG search and rescue crew and it was understood from the outset that a CCG vessel would be utilized as well. The vessel would have to meet certain requirements, these being:

1) Accommodations for 5 to 8 scientific personnel,
2) Extra crew to operate sensor equipment (some of which would be utilized 24 hours a day),
3) Capability for deployment of target, navigation buoy, and waverider buoy moorings,
4) Availability for 30 to 45 days uninterrupted time period in the fall of 1987, and,
5) Availability for operation in an open ocean area off the east coast of Canada in an area presenting minimal logistical problems (eg., off St. John's).

The objective here then was to designate a CCG vessel and crew meeting the criteria and to firm up logistical arrangements.

2.5 Investigation of CCG Radar Simulators

The primary objective here was to determine the utility of CCG radar simulators for deriving radar sweep widths. If realistic simulations could be undertaken then considerable savings could be made because the necessity would no longer exist for the use of a search and rescue crew and vessel for extended periods.

There were two secondary objectives. One of these was to investigate the use of the simulator to test whether radar operators tend to concentrate on one section of the radar display when looking for small, weak targets. The other was to investigate its use in examining the relationships between the length of time a radar operator is looking for targets and the percentage detected. If an experiment was to be carried out knowledge of these two factors would be most important in developing experiment methodology. The information will also be most useful in ongoing search and rescue operations where marine radar might be utilized.

3.0 RESULTS

The results are provided in the following subsections in terms of the objectives described in Section 2.0.

3.1 Investigation of Sensor Systems

Two sensor systems were investigated and evaluated. They were an infrared imaging system and a marine radar system (display and processing unit and/or full radar system). The following subsections describe the results.

3.1.2 Infrared Systems

Two infrared imaging system manufacturing companies were contacted. Both companies are involved in the manufacture of military grade systems for ship usage.

Spar Aerospace Limited is involved in the manufacture of infrared systems for the Canadian and United States (U.S.) Navies. A land based version of the system (tripod mounted) was demonstrated during a visit to their Ottawa facilities. Spar apparently does not manufacture a mounting or stabilization system for their shipborne system. Company representatives did offer to investigate building a pivoted mount system. A description of the sensor is provided in Appendix A.

Texas Instruments Incorporated of Dallas, Texas, manufactures a military grade infrared system. A description of the unit is also provided in Appendix A. The unit is equipped with a special 2-axis pivot mount and a yoke to allow easy viewing in any direction. The yoke is also designed to allow the operator to provide some stabilization capability and hence an ability to operate effectively when the ship is rolling. The company does not manufacture an automatic stabilization pedestal for the unit, although it is in the process of developing one.

Over the past few months the USCG has been testing various versions of the Texas Instruments system for drug interdiction purposes and for its potential use in search and rescue work. A representative from NORDCO Limited visited the USCG Research and Development Center in Groton, Connecticut. Discussions were held with Dr. Frank Replogle, Jr., who is responsible for research on infrared systems. He has been undertaking shipborne, shorebased, and airborne experiments for the purposes identified.

During the visit, a land version of the system was demonstrated. The system's electro-optics are identical to those of the shipborne system. The system was deployed on the roof of the USCG Research and Development Center overlooking Long Island Sound. A 19 foot boat and a 6 man canopied life raft were positioned offshore as targets. The demonstration took place in the afternoon with clear skies, 10-15 knot winds, and 2 foot seas.

Photographs of the images were taken using a polaroid camera with its lens positioned against the viewing eyepiece. Because of the difficulties related to the light and wind conditions only two usable photographs were obtained. Figure 1 shows the boat and the life raft at a range of 1900 metres using the narrow field-of-view. Figure 2 shows the boat (the life raft was behind the boat when this photograph was taken) using the wide field of view. The range was about 1800 metres. Differences in the contrasts are due to different settings on the system. The targets are clearly visible using the narrow field-of-view. The resolution is quite adequate. However, in the wide field-of-view mode the boat is only visible as a minute rectangular spot (only visible on the original photography), suggesting that it is close to the resolution of the system in size.

In later discussions with Dr. Replogle and a technician (R. Stachon) it was learned that the unit, deployed on a USCG ship, was not used for search. Rather it was used to verify or identify targets already seen visually or on radar. In a report describing a sea trial, the system was shown to be able to see through light fog or haze. During the same trial, as the sea state increased from about 2 to 4, it became virtually impossible to use. It was also found that utilizing the unit was difficult with ship roll amplitudes between 10° and 15°, and impossible at amplitudes of 20° or more. Moisture on the lens was found to virtually eliminate the system's imaging capability.

Mr. Stachon, after extensive testing of the system felt that by more judicious use of the controls (gain, contrast, narrow and wide field of view) the system could be made much more effective for search. He did note that in his own limited tests during a search, the targets were usually large vessels (freighters, fishing vessels, etc.). Mr. Stachon also felt that the yoke assembly made stabilization of the unit difficult and he suggested the unit could be made more effective with an improved yoke design.

Finally, during the sea trials it was found that detection range was reduced by about half when the system was used in the Caribbean as compared to those obtained in more northern latitudes (north of 35°). This was attributed to the high moisture content in the tropical areas and the subsequent increase in atmospheric attenuation.

Both Spar and Texas Instruments did offer their systems free of charge on a loan basis for the experiment. Spar suggested there could be some costs associated with the fabrication of a mounting system.

3.1.2 Radar Systems

Four radar manufacturing companies were initially approached in this investigation. These were:

Canadian Marconi Company,
Litton Systems Canada Limited,
Sperry Incorporated, Aerospace and Marine Group, and,
Racal-Decca Canada Limited.

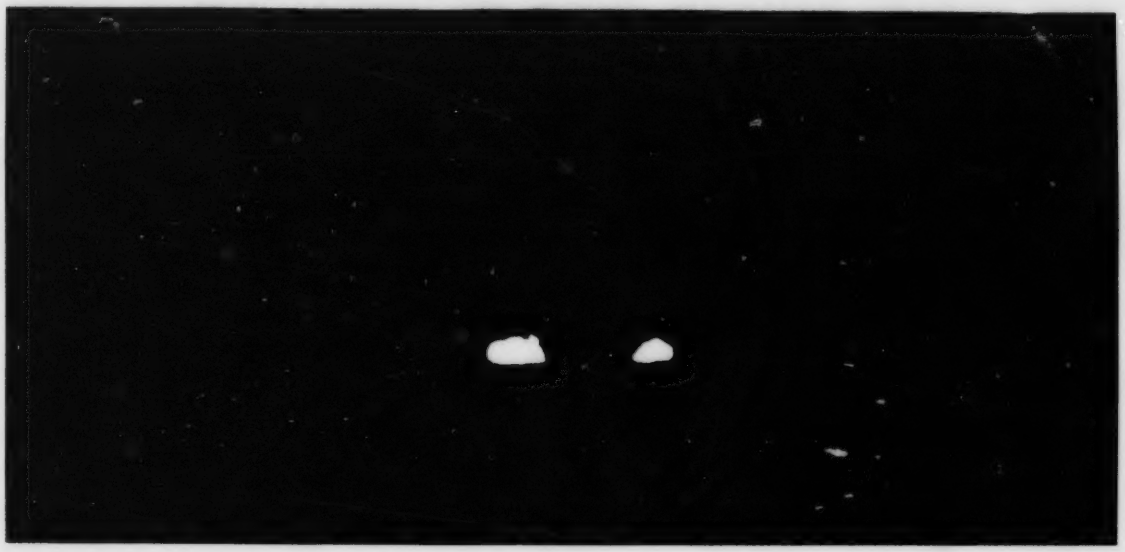

FIGURE 1 - Infrared image of small boat and life raft
using narrow field-of-view.

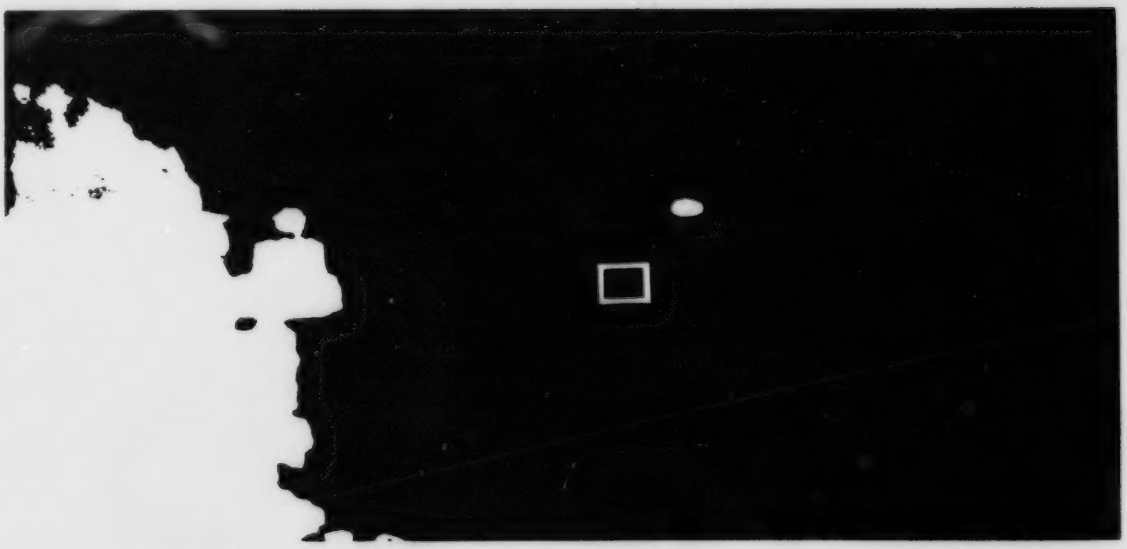

FIGURE 2 - Infrared image of small boat (inside square)
using wide field-of-view.

Canadian Marconi, in its capacity as a representative for the Raytheon Marine Company, recommended one of Raytheon's systems. One other company, Folsom Research Incorporated, was contacted as well although it is not a radar manufacturer. Folsom produces scan converters with some processing capability for marine radars.

Brochures on all the systems investigated are provided in Appendix B. The following subsections give the results of the evaluations and describe the pertinent features of each system. The descriptions will concentrate on the processing capability rather than the "front-end" sections (power output, antenna beamwidth, antenna gain, etc.) as the former is the most crucial aspect as far as this evaluation is concerned. Also, all the radar systems are X-band units and the displays are all raster types.

3.1.2.1 Raytheon Marine Company (Canadian Marconi Company)

The system recommended by Raytheon was their Pathfinder/ST unit. This is a new model which is currently going through its first production run. Only two units are in commercial use at this time and initial results, reported by Raytheon, indicate that in each case the units greatly out-performed conventional units in general. This includes the detection of weak targets. The system uses a series of processing schemes in order to provide a clutter free display, while maintaining its target detection capability. The primary features include:

1) Sea clutter reduction matched to the individual radar system parameters so that the system counteracts the clutter as close as possible according to theory;

2) Detection thresholding matched as closely as possible to the system noise level;

3) Pulse processing which samples individual returns so that noise or clutter "spikes" are removed and targets are maintained;

4) Beam processing which scans the successive returns within the resolution beamwidth eliminating noise and clutter by examining each hit and deciding whether it is a target in accordance to predefined detection probability criteria; and,

5) Scan-to-scan correlation (3 scans) which utilizes binary integration to eliminate clutter and maintain targets (the system adjusts for forward ship motion so that successive scans are properly registered).

The detection threshold technique may result in sub-clutter targets being missed unless a high false alarm rate is acceptable. The actual setting of the threshold is adjusted by the operator through the gain and clutter controls. Training and due care in its adjustment will be necessary to obtain an optimum setting.

Although the radar system is usually sold as a complete package the display, with all its associated processing, can be interfaced with existing radars. Care should be taken to ensure that the characteristics of the other radar are well matched to those of the Raytheon system. Otherwise performance degradation may result.

Raytheon is awaiting a decision from their senior management regarding the possibility of lending a unit for the experiment free of charge. A decision should be available shortly.

3.1.2.2 Litton Systems Canada Limited

Litton was unable to offer any system of their own. Its airborne unit could not be converted to a shipborne configuration. It was suggested that we should use a commercially available scan converter such as the Folsom Research Incorporated unit with an existing marine radar. Litton representatives did request that they be kept informed of the project status and suggested they might be of more assistance in the future.

3.1.2.3 Folsom Research Incorporated

Folsom does not manufacture radar systems. Rather it produces video and radar scan converters and digital image processors. The radar unit can be interfaced with any standard marine radar but is designed primarily for shorebased operation. The unit can undertake a recursive pulse-to-pulse average (3 pulses) and threshold levels can be set through look-up tables. These are the only critical processing functions provided. The brochure in Appendix B does not state that pulse-to-pulse averaging is done, but states that frame-to-frame (scan-to-scan) averaging is undertaken. This is an error and has been clarified by a company engineer.

The unit does not have a radar interference control and a special modification would have to be made to obtain target range and bearing information. Depending on the radar system there may be some charges for an interfacing unit. The company has offered to lend a unit for the experiment with the only charge being the costs of the modification and the interfacing.

3.1.2.4 Racal-Decca Canada Limited

Racal-Decca have recently introduced on the market a new series of radars called "Bright Track" radars which have a colour raster display. Pertinent processing features include:

1) Automatic sea and rain clutter reduction by clipping the analog signal on the lower end in accordance to the average signal content itself;

2) Detection thresholding set manually or using automatic clutter reduction (it is not clear exactly how this is achieved); and,

3) Scan-to-scan correlation (3 scans) which utilize binary integration (target is coloured in accordance with how many successive scans on which it is detected).

This radar has a colour display. One of the company senior research engineers did note that some people complained of a loss of their "night vision" when using it. The same engineer suggested that the radar may not be suitable for the type of performance expected in this experiment. Also, the scan-to-scan correlation does not take into account the forward movement of the vessel and therefore may miss weak relatively stationary targets.

The unit can be interfaced with an existing radar and the company has indicated verbally that a system could be made available free of charge for the experiment, providing installation and other costs are covered.

3.1.2.5 Sperry Incorporated, Aerospace and Marine Group

Sperry recommended their new RASCAR radar, which, like the Raytheon system is just now being introduced in the commercial market with only one or two systems actually in use. The brochure provided by Sperry did not give any information on signal processing techniques. The two processing descriptions provided here are based on discussions with marketing and engineering personnel, and are:

i) Constant False Alarm Rate (CFAR) processing (this is a resolution cell averaging process now in use in most military systems), and
ii) Pulse-to-pulse averaging (within each beam).

Both these are very powerful processing functions. The CFAR processing in most cases will aid in the detection of targets which are above the mean level of the background noise or clutter. In certain clutter situations, however, it may be detrimental to detection. The pulse-to-pulse averaging is a noise reduction process and should aid considerably in the enhancement of small targets.

3.2 USCG Participation

Although no formalized arrangements for USCG participation have been implemented, it is understood that the following forms of participation have been agreed to:

i) The lending of LORAN-C navigation equipment (two buoys plus a VHF receiver unit) to provide differential navigation capability;
ii) The lending of special passive radar reflectors whose cross section are known to some degree of accuracy; and,
iii) The active participation of at least one representative during a portion of the field experiment.

It is understood that all reports, results, and data related to the experiment will be made available to the USCG. Also, USCG representatives will be invited to all review meetings held throughout the project duration.

3.3 Identification of Navigation System

The selection of a navigation system for the offshore SAR experiment was a compromise, since conflicting factors, including availability, reliability, accuracy requirements, and costs have to be considered. The basic requirements of the navigation system are:

1. The system must function reliably 24 hours per day at a distance of approximately 30 to 50 nautical miles offshore.
2. It must provide position information in real time and allow for automatic archiving of the raw data for use in the analysis phase.
3. The system must be sufficiently accurate so that errors in computed lateral ranges are small.
4. It may or may not be independent of the ship's navigation systems.
5. Budgetary constraints require the costs be kept as low as possible.

A differential LORAN-C system (DLCS) is recommended since it appears to meet the requirements for accuracy and reliability, in addition to being relatively inexpensive. Individual user costs are low since there are no direct costs associated with the system transmitters, which are maintained by national government agencies, and because user equipment is widely available at competitive prices. System accuracy, which is adequate for general navigation purposes, can be improved when used in the differential mode. In a DLCS LORAN-C signal time differences (TD's) between each master/secondary transmitter pair are corrected for systematic and random propagation variations observed at fixed LORAN-C monitoring stations located in the area of operations. The following sub-section outlines the position data requirements for the project. This is followed by a brief summary of characteristics and costs estimates of the navigation and positioning systems that were considered. The recommended system is discussed in Section 4.0 of this document.

3.3.1 Position Data Requirements

Position data will be required 24 hours a day throughout the experimental period. Real time display of latitude-longitude co-ordinates is essential; video display of the ship's track is desirable. It will be necessary to achieve all raw navigation data at approximately 30-second intervals for processing during the analysis phase.

The accuracy of a navigation system is normally discussed in terms of its repeatable accuracy, relative accuracy, and absolute accuracy. Repeatable accuracy, which refers to the ability to return to the same location, is a function of availability and stability of the

radiopositioning system. Relative accuracy refers to the ability of two or more vessels to rendezvous. In this case stability of the signal is secondary to the ability of co-located receivers to detect, process, and output identical co-ordinates. Absolute accuracy is described in terms of differences between the position output by the system and the actual geographic co-ordinates.

For the SAR experiment it is the repeatable accuracy of the system which is most important for computing lateral ranges of the detection opportunities. However, absolute accuracy is also important for the deployment of search target moorings and for specifying the location of the experimental area and the position of the fixed waverider mooring in the Notice to Mariners.

Sweep width computations make use of the probability of detection (POD) determined using a multivariate linear regression analysis procedure. Typically, lateral range opportunities are binned in ranges of 0.1 nautical miles (185 metres). Errors in computed lateral ranges and incorrect binning of the data for the majority of opportunities are minimized when the radial position error is small. Radial error is usually described in terms of the distance root mean square (drms) error defined as:

$$drms = SORT\ (sigmaX^2 + sigmaY^2)$$

where sigmaX and sigmaY are the standard deviations of the two lines of position (LOP). This measure attempts to account for the ellipticity of navigation errors. The associated probabilities that position errors are within one drms and 2 drms are approximately 67% and 95% respectively. The exact percentage is dependent on the ellipticity of the error pattern (Roeber, 1983). For the offshore SAR experiment a maximum 2drms error of 100 metres is deemed acceptable. With this criterion a maximum of 67% of the position determinations will be within 50 metres of the correct position, and 95% with 100 metres.

3.3.2 Navigation and Positioning Systems Investigated

At the outset LORAN-C was the preferred system since it would likely entail the lowest cost. Its use in the conventional hyperbolic mode as well as in rho-rho and differential mode has been investigated. A comparison of accuracies attainable and approximate costs has been made with dedicated positioning systems available from East Coast firms specializing in navigation and positioning. These systems included Syledis, ARGO, LORAN-C rho-rho and the shorter range miniranger/trisponder systems. Type, frequency, accuracy ratings (2drms value), and budgetary estimates of dedicated systems are contained in Table 1.

LORAN-C rho-rho is the least expensive since deployment, operation, and maintenance of the shore-based transmitters are not required. Note that LORAN-C rho-rho mode requires that an independent positioning system, such as GPS or Transit, be available for setting and calibration. These costs have not been considered in Table 1.

System	Sercel Syledis	ARGO	LORAN-C rho-rho	Mini-Ranger	Trisponder
Type	circular	circular	circular	circular	circular
Frequency	420-450 MHz	1.6-2.0 MHz	100 Kz	5.4-5.9 GHz	8.8-9.5 GHz
Range	100 km	300 km	300 km	40 km	40 km
Accuracy (2drms)	5-15 m	8-25 m	50 m	5-20 m	3-12 m
Budgetary Estimates:					
Mobilization-Demobilization					
land stns	$ 2500-8000	$ 4500	-	$ 2500	$ 2500
vessel	2000-7000	2500	$ 200-7000	2000	2000
Day rates (assumes 3 land stations)					
land stns	$ 450-675	$ 705	-	$ 375	$ 375
mobil sys	150-275	375	$ 265-390	225	225
spares	150-225	325	105-150	200	200
Personnel					
navigator	300-375	375	300-375	375	375
shore tech.	300-325	325	300-325	325	325
Estimated totals assuming 3 land stations, 2 navigators, 1 day shore station maintenance, 45 day program, and no spares:					
TOTAL COST	$71200-79425	89675	48000-51850	65575	65575

TABLE 1 - Comparisons Among Dedicated Surface Radiopositioning Systems

The Navstar Global Positioning System (GPS) is a satellite-based navigation system operated by the U.S. Department of Defence. With only 7 satellites operational (June 1987) coverage is limited to approximately 6 hours per day. With GPS in Standard Positioning Service (SPS) the 2drms value is 100 metres, in Precise Positioning Service (PPS) the 2drms statistic is 18 metres (Morgan, 1986). The entire constellation of 21 navstar satellites is expected to be fully operational in 199i, giving worldwide coverage 24 hours a day. In comparison, the older Navy Navigation Satellite System or Transit System has a 2drms of 50-100 metres with worldwide position fixes available approximately every 90 minutes on average.

3.3.3 LORAN-C Navigation System

LORAN-C is a pulsed, low frequency, long range hyperbolic navigation system having reasonably good coverage over East Coast waters 24 hours a day throughout the year. Two chains are available off eastern Canada. The Canadian East Coast chain rate (5930) provides coverage over the Gulf of St. Lawrence and the Atlantic Waters off Nova Scotia and south of Newfoundland. The Labrador Sea chain rate (7930) covers the south and east Labrador Sea and the waters off east and northeastern Newfoundland.

Position accuracy is primarily a function of system geometry (lane expansion and LOP angle of crossing), receiver sensitivity, and signal propagation variations. Morgan (1986) reports that the 2drms accuracy measure is 50 to 500 metres for LORAN-C. Skywave interference is known to be a problem off northeast Newfoundland, particularly at twilight, especially with some older models of receivers (pers. comm. J. Butler, CCG Newfoundland Region). Radio interference from other radio transmitters operated in the vicinity may also affect LORAN-C reception (Canadian Coast Guard, 1987).

Position is determined by plotting the observed TD for each master/secondary pair (at least two) on the nautical chart, or by using an appropriate algorithm to compute the latitude-longitude of the point of crossing. An additional secondary phase correction factor (ASF), which is due to the actual propagation path being at least partially over land rather than an all seawater path, must be included in the algorithm. Theoretical ASF corrections are included on the LORAN-C lattices plotted on the charts. As an example, over the Canso Bank off Nova Scotia the ASF correction for 5930X is approximately -2.9 us (microsecond) and for 5930Y it is about -2.5 us. A receiver resolution of 0.1 us means an actual resolution of 38 metres for 5930X and 16 metres for 5930Y on the Canso Bank. Accordingly, the ASF corrections amount to approximately 1100 metres and 400 metres for the 5930X and 5930Y lines of positions, respectively, in the area.

3.3.4 Differential LORAN-C

The LORAN-C hyperbolic radiopositioning system in the differential mode offers improved accuracy of position information in comparison with fixes made in the conventional hyperbolic mode since time variability in

the measured time differences (TD's) between each master/secondary transmitter pair is removed. This variability, which has both systematic and random components, is due to:

1. Synchronization errors in the time intervals between the master and slave transmissions;
2. Changes in the surface conductivity along the propagation path; and,
3. Small differences in the propagation rate of the LORAN-C ground wave signal resulting from changes of the vertical lapse rate of the refractive index, a function of temperature and humidity profiles along the propagation path (Doherty and Johler, 1976).

Past work (e.g. Taggart, 1983) has shown that seasonal changes may vary about $\pm$ 0.3 to 0.4 us around the mean while diurnal changes of 0.2 to 0.3 us are quite possible. Marked changes of 0.1 to 0.15 us have been observed in the wake of a sharp cold frontal passage. Random variations of approximately 0.15 us associated with chain control effects have been seen in U.S. data. Canadian Coast Guard personnel state that this discrepancy must be kept within $\pm$ 0.1 us and is normally kept within $\pm$ 0.04 us (pers. comm. Gaudy, CCG Station, St. Anthony).

With a differential LORAN-C system, time differences for each master/secondary transmitter pair are monitored at fixed locations. The differences from the long term means at each location are computed (delta ASF) and used to correct TD's observed aboard the vessel. A number of approaches may be used to supply the vessel with the delta ASF data. The corrections may be taken from a single monitoring station in the vicinity or interpolated from a multi-station array. The data are normally provided periodically and used as predictions until the next update is received. Reporting on a series of tests, Bruckner and Westling (1985) found that the Least Square Error method reduced the rms prediction error by more than other technique tested. The corrected TD for each master/secondary pair is then computed from:

$$TD(cor) = TD(obs) - CD - BT + ASF + \text{delta ASF}$$

where CD is the assigned master/secondary coding delay and BT is the baseline signal travel time.

A differential LORAN-C system appears to offer sufficient accuracy for the SAR experiment at relatively low cost. The recommended system is discussed in some detail in Section 4.0.

3.4 Designation of Ship, Location, and Time Frame for Experiment

It is understood that the new CCGS "Sir William Alexander", operating out of the Maritime Region, will be available for the experiment in the fall. The ship will be on active search and rescue duty although attempts will be made to minimize any disruptions during the 30 to 45 day period experiment. At the time of year for the experiment the operational area

for the ship will have minimal possibilities for a search and rescue incident. Detailed specifications on the ship have yet to be made available, but it is understood that there is sufficient accommodation for the 5 to 8 scientific staff and the extra crew required for the experiment. The exact location for the experiment will be finalized during discussions with the Maritime Region CCG staff, although tentatively, the Canso Bank area has been selected. This is within the operational area for the ship, has minimal ship traffic, good LORAN-C coverage, and good bathymetry from the point of view of moorings.

The exact time frame for the experiment has still yet to be finalized although a start date of September 15, 1987 is being considered. The finalization of the time frame depends primarily on the overall period in which the ship will be available and the availability of the radar system. The latter limitation will probably be the more crucial.

3.5 Investigation of CCG Radar Simulators

Investigation of the feasibility of undertaking SAR experiments using one of two navigation simulators belonging to Transport Canada was conducted as part of this phase of the project. Specifically, the equipment was examined for use in undertaking two types of experiments:

1. to carry out radar search experiments with sufficient realism to determine accurate sweep width relationships for marine radar SAR work (In order to do this, the equipment must be capable of simulation of search patterns, realistic simulation of target return characteristics, and accurate representation of clutter.), and,

2. to investigate human factors relating to an electronic search for relatively weak targets using a standard X-band marine radar unit (In particular, this work would involve examination of the observer's "area of concentration" on the PPI display and the degradation of ability to discriminate targets due to observer fatigue and similar factors.

One of the navigation simulators investigated is located at the CCG College in Sydney, Nova Scotia, and the other is located at the Transport Canada Training Institute (TCTI) in Cornwall, Ontario. Both systems were manufactured by The Solartron Electronics Group Limited in the U.K.

3.5.1 CCG College Navigation Simulator, Sydney, Nova Scotia

The following list provides a summary of the capabilities of the CCG navigation simulator to perform SAR experiments:

1. Any specified search pattern can be simulated.
2. Radar targets can be positioned in any desired location.
3. There is very limited ability to vary target strength and size.
4. Clutter simulation is not accurate, and is either on or off. No user facility is available to re-program clutter. Targets can always be identified whether the sea clutter is on or off.

5. Simulated transmitter parameters such as signal pulse length, antenna rotation rate, and so forth are not adjustable.
6. Computation of lateral range is possible.
7. Up to 12 targets may be positioned in fixed locations or set drifting if desired.
8. A flat bed plotter is available to plot track and target positions at virtually any interval desired.
9. Simulator software is written in DEC Macro II for a PDP-11/35 as stand alone applications.

3.5.2 TCTI Navigation Simulator, Cornwall, Ontario

The following list outlines the capabilities of the TCTI navigation simulator for SAR experiments:

1. Any specified search pattern can be simulated.
2. Up to 24 radar targets can be positioned in any desired location.
3. Target strength and size may be varied in steps allowing relatively weak targets to be simulated. However, target characteristics are not adjustable during an experiment.
4. Clutter simulation is not accurate, but can be adjusted in intensity and range (decaying to a minimum at 3 nautical miles); the clutter pattern cannot be readily re-programmed. Video levels of the targets and clutter are adjustable by the system operator during a simulation. Variable target size and strength, adjustable clutter amplitude, and adjustment of video level effectively reduces the ability to discriminate weak targets in the clutter field.
5. Pulse length is menu adjustable between 0.2 us and 3.0 us, and antenna beam width is variable between 0.7 and 2.1 degrees to the 3 db point in steps of 0.17 degrees. By modifications to code, antenna rotation rate is adjustable to a maximum of 30 rpm and pulse repetition rate are adjustable to a maximum of 2 kHz.
6. Computation of lateral range is possible.
7. Flat bed plotter is available to plot track and target positions at virtually any interval desired.
8. Simulator software runs on a PDP-11/34 as a stand alone application software package.

Conclusions regarding the use of these simulator systems to conduct sweep width experiments and to investigate human factors related to search practice are contained in Section 4.0.

4.0 CONCLUSIONS AND RECOMMENDATIONS

4.1 Investigation of Sensor Systems

If any shipborne infrared experiments are to be undertaken, it is clear that the Texas Instruments unit is more suitable than the Spar unit because it is designed specifically for shipborne usage. The lack of a stabilization yoke assembly or any kind of mounting system and the fact that the system is not designed for shipborne operation would seem to place the Spar system's potential for successful operation in this experiment at a low level. The system manufactured by Texas Instruments is more suitable. However, from operational tests undertaken by the USCG it is apparent that the utility of even this infrared system may be very limited. It is therefore recommended that an infrared system not be tested in this experiment. The fundamental problems are the poor resolution associated with the wide field-of-view, which is necessary for search, and the inability to use the system in any significant sea conditions.

It is apparent that the new Raytheon and Sperry radar systems provide the most advanced processing schemes. The Racal-Decca system is not even recommended by its own engineers, while the Folsom processing and display system is not designed or configured for shipborne usage. All the systems can be interfaced with existing radars, eliminating the need for installing new antennas and tranceivers.

It is impossible at this time to determine which of the Raytheon and Sperry systems will provide the better performances. Both undertake processing schemes considerably advanced over those of existing systems. Availability is expected to determine which of the radar systems will be used. On this issue, there is considerable doubt regarding the availability of the Sperry system. This should be resolved within the next month.

4.2 USCG Participation

The USCG appears to be very interested in the project and will participate at least to the levels stated. In order to ensure and, indeed, encourage further participation, it is recommended that some form of formal arrangement be made directly between the CCG and the USCG. This can only benefit both countries.

4.3 Specification of the Navigation System

The recommended navigation system is a differential LORAN-C system. The USCG has indicated that two LORAN-C buoys may be available for loan to the CCG to provide differential data during the offshore SAR experiment. The two buoys will be deployed in the vicinity of the project area. If possible one will be set up at a fixed location on land, otherwise, both units will be moored with taut mooring systems to reduce the horizontal excursion to a minimum. Position data from the buoys is available, to a resolution of 0.1 us, in real time by VHF transmission averaged over a

minimum of 10 minute intervals. General specifications of the LORAN-C buoys are contained in Appendix C. A micro-computer interfaced to a VHF receiver aboard the SAR vessel will be used to compute the delta ASF data for each master/secondary pair for each buoy.

It is recommended that a Raytheon Marine Company RAYNAV 750 S/D LORAN-C receiver be used onboard the ship to determine TD's and to compute the latitude-longitude co-ordinates. Prototype units have been used by the USCG in recent differential LORAN-C tests (Blizard and Slagle, 1987). These units, now in production, have a number of important features:

1. Automatic or manual input of ASF data;
2. Capability of differential LORAN-C operations; and,
3. Automatic generation of standard search patterns.

Appendix C contains a copy of a brochure that outlines the capabilities of the unit.

The receiver will pass the observed TD's to the microcomputer for use in an interpolation routine. The interpolated delta ASF data for each master/secondary pair will then be passed to the RAYNAV unit for position computation. ASF data will be used from the unit's internal routine or input manually from theoretically predicted data available from the Canadian Hydrographic Service, Dartmouth, NS. Alternatively, the position computation may be done on the microcomputer using an algorithm such as that described by Shudde (1984). Raw and processed data will be logged in a disk file at 30 second intervals. It is desirable to use a Raytheon NWU S1 Color Video Plotter in conjunction with the RAYNAV 750 S/D receiver to provide a continuous video image of the ship's track in relation to the search target positions during the experiment. Alternatively, plotting software for the microcomputer may be developed.

In order to have the system in place for an autumn experiment it is mandatory that the RAYNAV 750 S/D LORAN-C receiver be ordered as soon as possible. These LORAN-C receivers are expected to be available at the end of July 1987. It will also be necessary to obtain a suitable microcomputer (e.g. Compaq 286 with two floppy disk drives and two RS232 ports), a USCG LORAN-C buoy and VHF receiver as soon as possible. An estimated four to six man weeks will be necessary to assemble and fully test the system.

4.4 Designation of Ship and Time Frame

The CCGS "Sir William Alexander" has been tentatively identified as the ship on which the offshore SAR experiment will be conducted. One concern however is that the vessel will be on active search and rescue duty. While the importance of this duty cannot be overstated, it is important that disruptions to the experiment be minimized.

The time period for the experiment cannot be specified until the delivery date for the radar system is confirmed by the manufacturer. This should be clarified in the near future. The overall time frame for ship availability needs to be clarified as well.

4.5 Investigation of CCG Radar Simulators

The facility at the CCG College in Sydney, which was installed about 1974, appears to serve very well as a navigation simulator for the training of ships officers. It is, however, entirely inadequate to serve as a fully functional radar simulator with which to conduct SAR experiments. The primary reasons are the inability to simulate small and weak radar return signals, the poor representation of clutter, and the fact that position information is not available in digital form. These problems cannot be readily solved since the system is proprietary to the Solartron Corporation.

The navigation simulator housed at the TCTI is a more up-to-date version (c1981). As a consequence, it contains a number of improvements which may very well facilitate the testing of human factors affecting SAR radar search practice. The simulator cannot, however, be used to carry out experiments to derive sweep width tables or formulations.

In order to determine reliable sweep widths for radar searches using a marine navigation simulator, it is mandatory that the facility accurately simulates the echo from a range of target types using various radar transmitter/receiver parameters in realistic sea and precipitation clutter fields. The simulated return needs to be related to radar cross section, which, in turn, varies as a function of dimensions, orientation, and composition of the specific target. In addition, the echo needs to be a function of the range between the antenna and the target, the wavelength, antenna gain, and the power transmitted. The simulated return signal then needs to be sensitive to the normally adjustable radar parameters, such as beamwidth, pulse length, pulse repetition rate, and scanner rotation rate. The sea clutter model must adequately represent clutter conditions to be expected in a given sea state which may be expressed in terms of significant wave height and a representative wave period or with model wave spectra or, possibly, to previously observed wave spectra. Accurate simulaton of precipitation clutter is necessary as well. The model should include a probability function that accurately describes the chances of receiving a return signal in a given sea state. Since none of these factors is adequately represented, operational sweepwidths cannot be determined using the Solartron navigation simulator at TCTI.

As outlined above, since small weak targets of comparable intensity to the adjustable sea clutter intensity can be generated on the TCTI simulator, it appears possible that the facility can be used to investigate certain human factors related to radar searches. It appears quite likely that an experiment can be developed that effectively determines whether experienced ships officers are biased in their examination of the PPI display and, if so, what portion(s) of the screen tends to be favoured by individual operators. In addition, a statistical analysis of the time variability of the probability of detection scores that result will provide a measure of the fatigue factor and, possibly, suggest the frequency at which radar watchkeepers should be rotated to maintain an acceptable probability of detection.

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APPENDIX A

INFRARED SYSTEMS BROCHURES

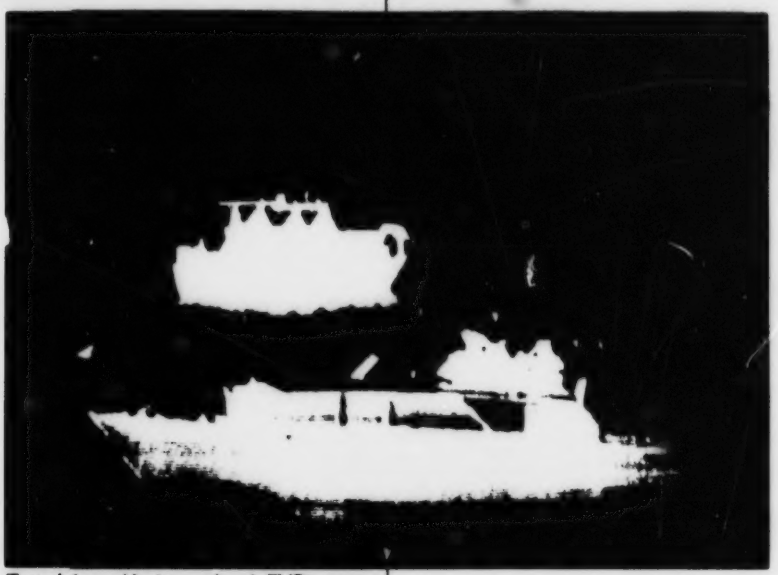
TEXAS INSTRUMENTS

LIGHTWEIGHT SHIPBOARD ELECTRO-OPTICAL SENSOR

Lightweight Shipboard Electro-Optical Sensor

The Lightweight Shipboard Electro-Optical Sensor (LSEOS) is a passive infrared imaging and surveillance system used for area surveillance, target detection, and search and rescue missions 24-hours a day and in adverse weather conditions.

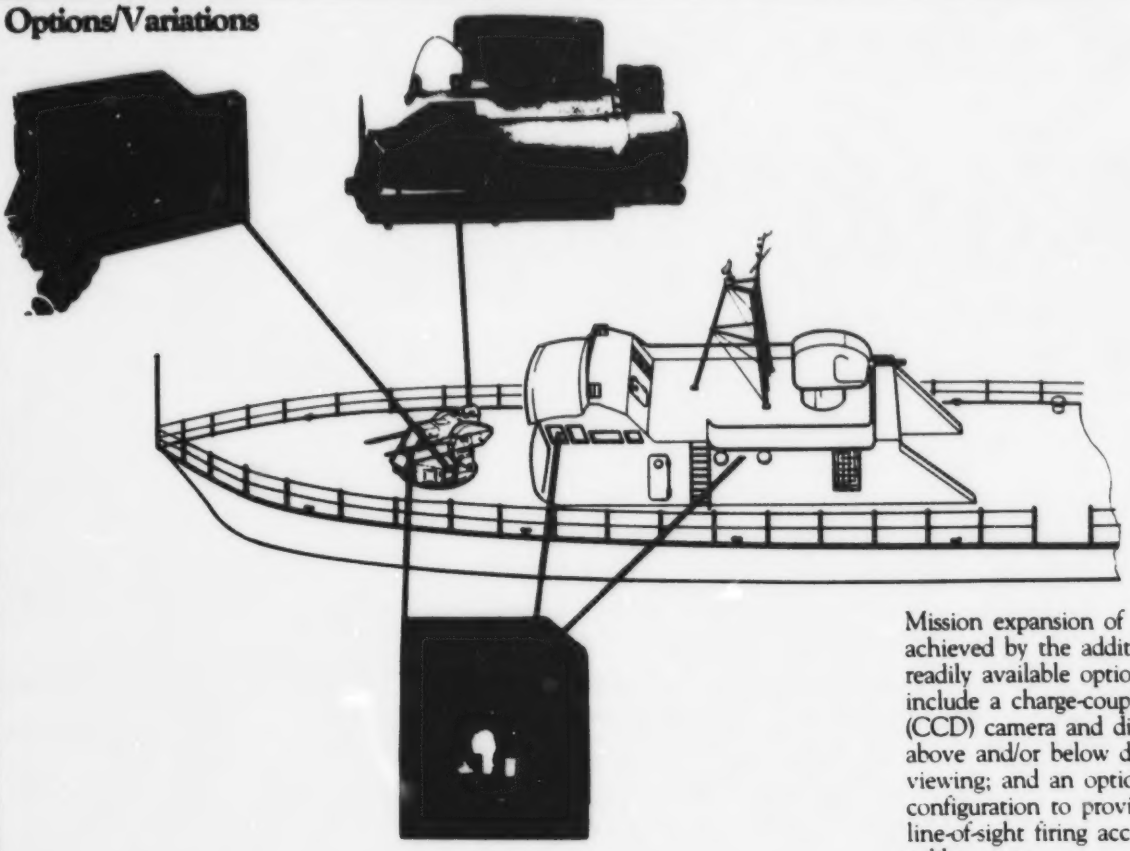
Based on an existing U.S. DoD FLIR system developed by TI specifically for the harsh naval environment, the LSEOS has completed technical and operational evaluation for U.S. defense systems and is available for immediate deployment. The LSEOS incorporates a closed-cycle cooler for continuous operation, a two-axis pivot mount, and a power conversion unit (PCU). The use of field proven hardware, already in volume production, not only enhances affordability but also presents significant life cycle cost savings.



Typical forward-looking infrared (FLIR) imagery, recorded under total darkness

The military qualified LSEOS is currently in volume production and has been deployed. It is pictured here with the optional CCD camera and remote display unit.

Options/Variations



Mission expansion of the LSEOS is achieved by the addition of some readily available options. These include a charge-coupled device (CCD) camera and display unit for above and/or below deck remote viewing; and an optional gun mount configuration to provide 24-hour, line-of-sight firing accuracy for small caliber guns.

Applications

- Pilotage, navigation, escort
- 24-hour reconnaissance and surveillance
- Threat detection and identification
- Search and rescue
- Station keeping
- Fire control
- Command and control
- Real imagery relayed to command center
- Target tracking
- Target ranging

Specifications

Size	18″ × 20″ × 18″ (sensor) 12″ × 12″ × 7″ (PCU)
Weight	38 pounds (sensor) 19 pounds (PCU)
Power requirements	36 watts
Voltage	115V, 60 Hz
Resolution (wide)	0.5 mrad
Resolution (narrow)	0.167 mrad
MRT	0.36°C f_o
NET	0.2°C
FOV (wide, 3X magnification)	3.4° × 6.8°
FOV (narrow, 9X magnification)	1.1° × 2.2°
Cooldown time	6 minutes to specified MRT 3 minutes to useable video
Operating	8 to 12 microns

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SPAR AEROSPACE LIMITED

TIGER-EYE

In performance
In reliability
In combat

. . . he can depend on Tiger-Eye!

Spar Aerospace Limited

Defence Systems Division
1235 Ormont Drive
Weston, Ontario, Canada M9L 2W8
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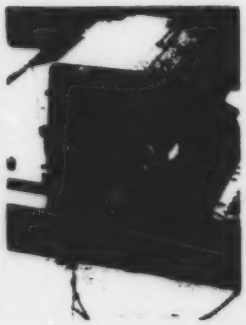
Telex 065-27332

SPAR

Tiger Eye - bred from its conception to out-perform and out-survive all other man-portable thermal imaging systems available. With **Tiger Eye** the observer is able to deploy further from the forward edge of the battlefield reducing his vulnerability to detection and counterfire while still meeting all mission requirements.



Tiger Eye - the evolution of over five years of development and field trials is a rugged "soldier's" system that is fast into and out of action, light-weight and effective in combat.

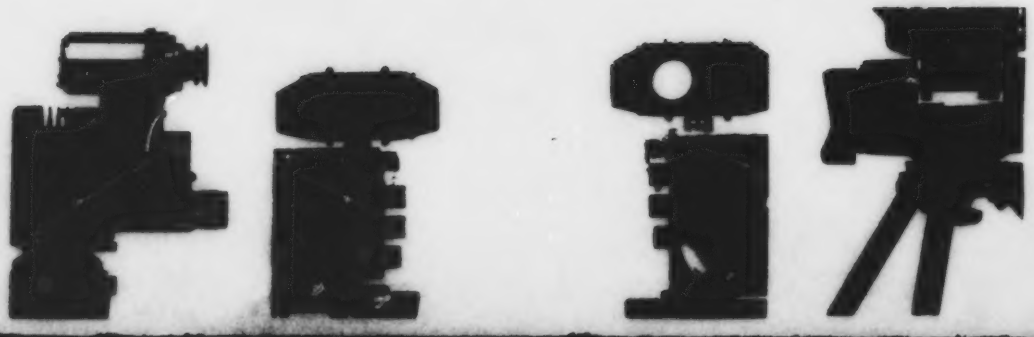
Advanced Canadian and U.S. technology provides **Tiger Eye** with unique capability today and will readily accommodate new developments to counter future threats.

The **Tiger Eye** FLIR has undergone extensive performance and environmental testing proving its ability to withstand the rigours of the modern battle field.

Tiger Eye is a production ready, field proven system backed by a heritage of over 1,000 systems using the same standard modules that are currently fielded internationally in military combat vehicles.

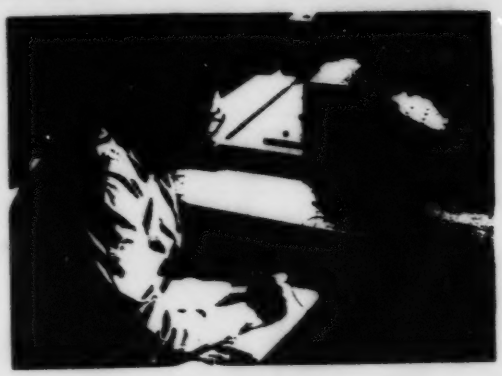
Equipment configuration

Field proven and production ready today!



In performance
In reliability
In combat

Field testing, Feb. 1987 at the Defence Research Establishment, Valcartier.



Environmental testing – April 1987. Vibration testing, Kanata Ontario.

Human Engineered for optimum performance and mission effectiveness

He can depend on Tiger Eye!

The **Tiger Eye** Thermal Observation Device places in the hands of the forward observer the latest generation of tactical surveillance systems.
Low power consumption, silent operation and the fastest into and out of action time available is combined with the highest quality TV compatible imagery making **Tiger Eye** mission effective.
By detecting minute differences in temperature, buildings, fuel storage areas, military vehicles and other potential targets appear as distinct heat sources that can be recognized and targeted.
By day or by night and during adverse weather, **Tiger Eye** identifies the threat...First. Immune to all known countermeasures and not blinded by flares, searchlights or lasers, **Tiger Eye** can penetrate most natural and man-made screens, including currently deployed smokes and camouflage, enhancing its utility in daylight as well as at night.
Using the integral laser rangefinder and precision goniometer the operator can coordinate artillery fire direction or forward air strikes.
The **Tiger Eye** turns darkness into daylight putting the enemy at risk around the clock.

Tiger Eye Performance Advantage

Parameters		
	Narrow Field of View	2 x 3 degrees
	Wide Field of View	7 x 10 degrees
	MRT	< 1.0° C at 4ey mrad
		(< 0.5° C typical)
	Magnification	8.3 x 2.3 x
	FOV	.13 mrad
	Aperture	4.5 inches
	F no	F 1.2
	Dead Noisy Channels	NONE
	Spectral Band	7.5 - 12μm
	Display	CRT -standard
		525 line video
	Boresight Retention	0.1 mrad
	Range Capability	Exceeds Operational
		Requirements
	Countermeasure Resistant	YES
	True Horizon Definition	YES
	Anti-Blooming	YES
	Remote Displays	YES
	Remote Operation	YES
	Weight	11kg
	Into Action time	4.5 min. with cooler
		45 seconds with gas bottle
	Out of Action and Mobile	in 2 seconds flat

Spar Aerospace Limited, meeting the world's needs in tactical infrared surveillance for over 20 years.

SPAR has everything it takes...Today

The Technology

Since its formation almost two decades ago, Spar has been building a team of talented people experienced in the development of military Electro-Optical systems. Our foresight and vision has enabled our engineers to pioneer and develop the technologies and systems required to ensure that our defence and maritime systems will perform effectively both today and tomorrow.

The Experience

We have earned a reputation for consistently delivering quality products that meet or exceed performance requirements, corporate commitment to research, development and Spar's product excellence is unparalleled.

The Resources

We share Spar's physical, financial, technological and human resources as well as the management philosophy that has made Spar one of our nations most productive and efficient developers and manufacturers of high technology products.

Spar's Defense System Division is now developing and manufacturing effective, affordable infrared systems and integrating them into platforms to match the specific challenges our customers face both today and tomorrow.

Systems under development and in production include:

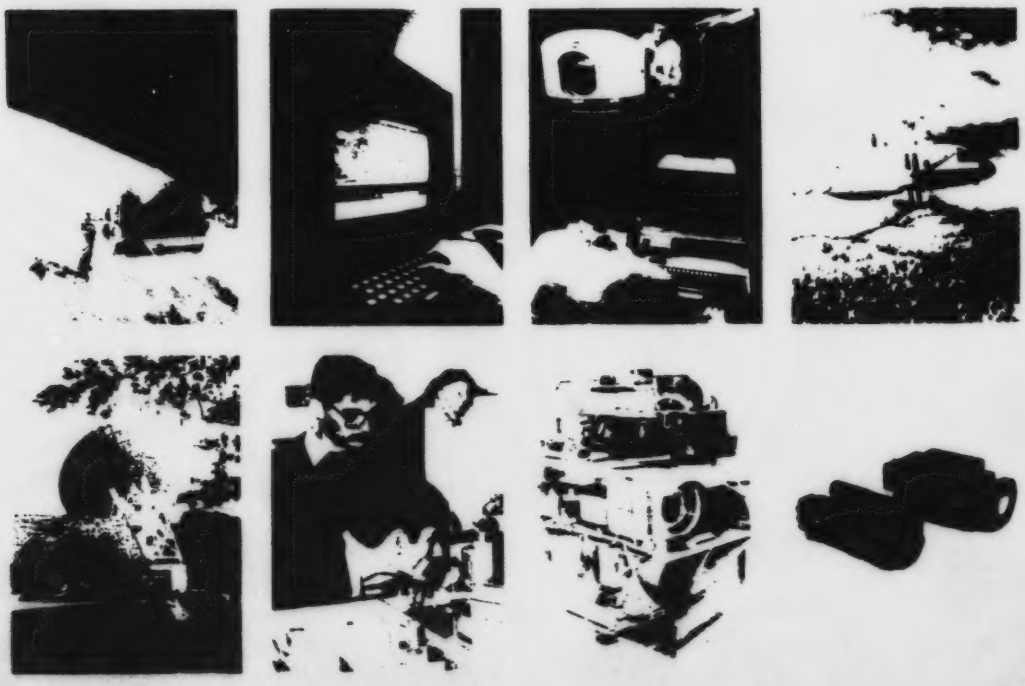
The **AN/SAR-8** An Infrared Search and Target Designation system undergoing Full Scale Engineering Development (FSED) for the Navies of Canada and the United States. This system complements radar in detecting and tracking aircraft missiles and ships for engagement by the ship's combat system;

The **ADATS FLIR** In production for the Canadian Forces Low Level Air Defence (CF-LLADS) system. Based on U.S. Common Module technology the Spar FLIR is a major component of the ADATS system extending its operating capability into night and poor visibility conditions;

The **CP 140 Maritime Patrol FLIR** Our first system for the Canadian Forces is a cost effective replacement for the now obsolete OR 5008A. It has seen almost 6 months of operational flight trials during which it has consistently out performed the original equipment.

The **P.M.S. FLIR** Built for LTV Aerospace, it is currently undergoing evaluation and trials in support of the U.S. Army Pedestal Mounted Stinger (PMS) air defence program.

These systems are the result of many years of company funded research and development to create a new standard in Thermal Imaging technology - **Tiger Eye**.



APPENDIX B

RADAR SYSTEMS BROCHURES

RAYTHEON MARINE COMPANY

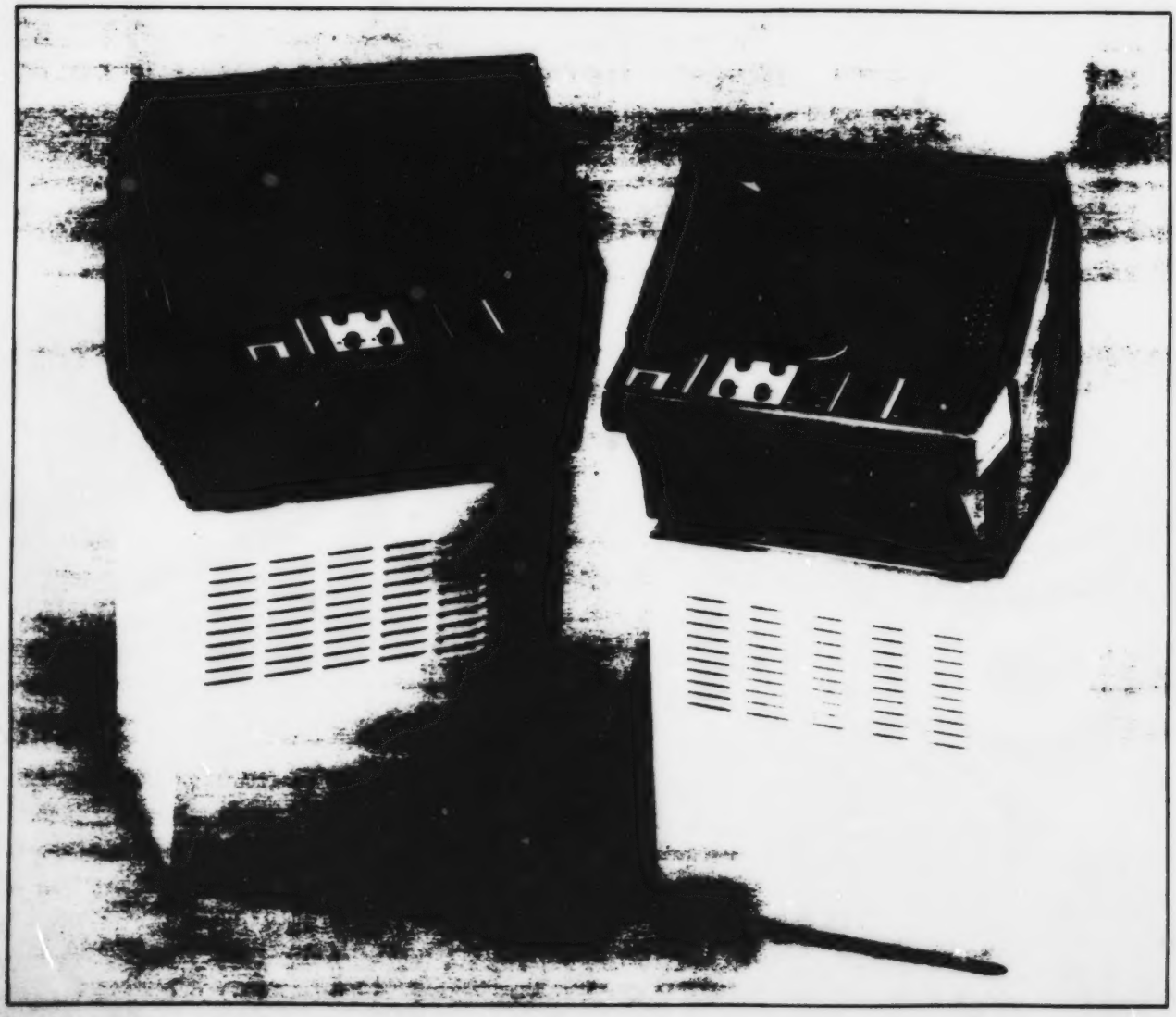
Raytheon

SOLD AND SERVICED IN CANADA BY

CANADIAN MARCONI COMPANY

COMMERCIAL COMMUNICATIONS DEPARTMENT

PATHFINDER®/ST Radar and ARPA Systems



Raytheon Introduces Revolutionary PATHFINDER®/ST Radars

The Leader for Over 40 Years

Expanding on the radar technology it developed for the U.S. Navy, in 1946 Raytheon introduced the first commercial MARINERS PATHFINDER 3 and 10-cm Marine Radars. Since then, Raytheon has been the world's leading supplier of radars for commercial, recreational, and military vessels of all sizes and types.

Raytheon's leadership results from engineering and manufacturing excellence, innovation based on leading-edge technology, and the belief that quality starts with fundamentals.

Superior Technology (ST): Another Raytheon Milestone

With the introduction of PATHFINDER / ST Radars, Raytheon again sets new performance standards for the industry.

This complete line of revolutionary commercial radars offers IMO compliant ARPA, True Motion/Electronic Plotting, and Relative Motion displays, with levels of performance never before available.

Seeing Invisible Targets

Raytheon's PATHFINDER / ST Radar combines the very latest raster display technology and vastly superior signal processing with a high performance, high reliability transmitter/receiver design. This Superior Technology – which gives this radar its name – provides performance far exceeding that of conventional PPI and raster display radars. While advances in receiver design are significant, the key to the superior performance of the PATHFINDER / ST Radar is its raster display signal processing capabilities.

This unique Raytheon signal processing is so effective that noise, clutter, and interference are "processed out" while targets are clearly and distinctly displayed. For example, it is possible for the PATHFINDER / ST Radar to "see" and display targets inside heavy rain or sea clutter, even though these targets may be invisible to other radars.

Operator Friendly

PATHFINDER / ST Radar Displays provide standard-looking PPI presentations made from scan-converted radar data which is refreshed 50 times every second. This eliminates the operator-tiring flicker found in other radar systems.

Raytheon Displays use a rectangular CRT with navigation and ARPA data logically placed around the circular PPI. The result of extensive ergonomic studies, PATHFINDER / ST Displays substantially reduce operator fatigue and confusion.

Upgrading Existing Radars

All PATHFINDER / ST Radar Displays (TM/EP and ARPA) may be used to upgrade existing 3 and 10-cm radars.

With older Raytheon Bright Display Radars, new PATHFINDER / ST Radar Displays can replace existing displays in single and dual systems using an internal interface module.

With adaptors, PATHFINDER / ST Radar Displays may also be used as add-ons for radars of most other manufacturers. In this case, Raytheon PATHFINDER / ST Radar units act as high-performance repeaters for existing displays. The interface option is flexible, adapting to most radar video, trigger, and azimuth (synchro or resolver) conventions. Installations are simple and straightforward.

34 and 25-cm diameter PATHFINDER / ST PPI displays meet IMO size requirements for 16 and 12-inch CRT displays.

Exclusive Superior Technology signal processor detects and displays weak targets typically lost in noise and clutter. Unique RAIN-RATE control, together with a computer-assisted Sea Clutter control, dramatically reduce rain and sea clutter, even in the harshest environment.

ARPA Model automatically tracks 20 targets, provides IMO-required vector and readout information. Has Manual Acquisition using trackball, Auto Acquisition with true or relative acquisition zones.

Basic TM/EP Model includes North Stabilisation, True Motion, and Electronic Plotting. Course, speed, range, bearing, vectors, CPA, TCPA displayed for plotted targets... navigation line, true marks, and trial manoeuvre standard.

Safety-Coded CPA Circle, a display feature that quickly shows course selections that result in safe CPAs.

Target true wakes (electronically-generated afterglows) highlight speed and direction of moving targets.

Special, low-noise receivers and more reliable low-power transmitters equal or better the performance of high-power systems.

X-band, 3-cm, 25-kW transceiver mounted below-deck or aloft with 9-foot (274 cm) or 7-foot (213 cm) antenna.

S-band, 10-cm transceiver mounted below-deck (30 kW) or aloft (10 kW) with a 12-foot (366 cm) antenna.

PATHFINDER / ST Radar Displays may be used as add-ons for most existing radars as well as being direct replacements for the displays in older 3 and 10-cm Raytheon Bright Display Radars.

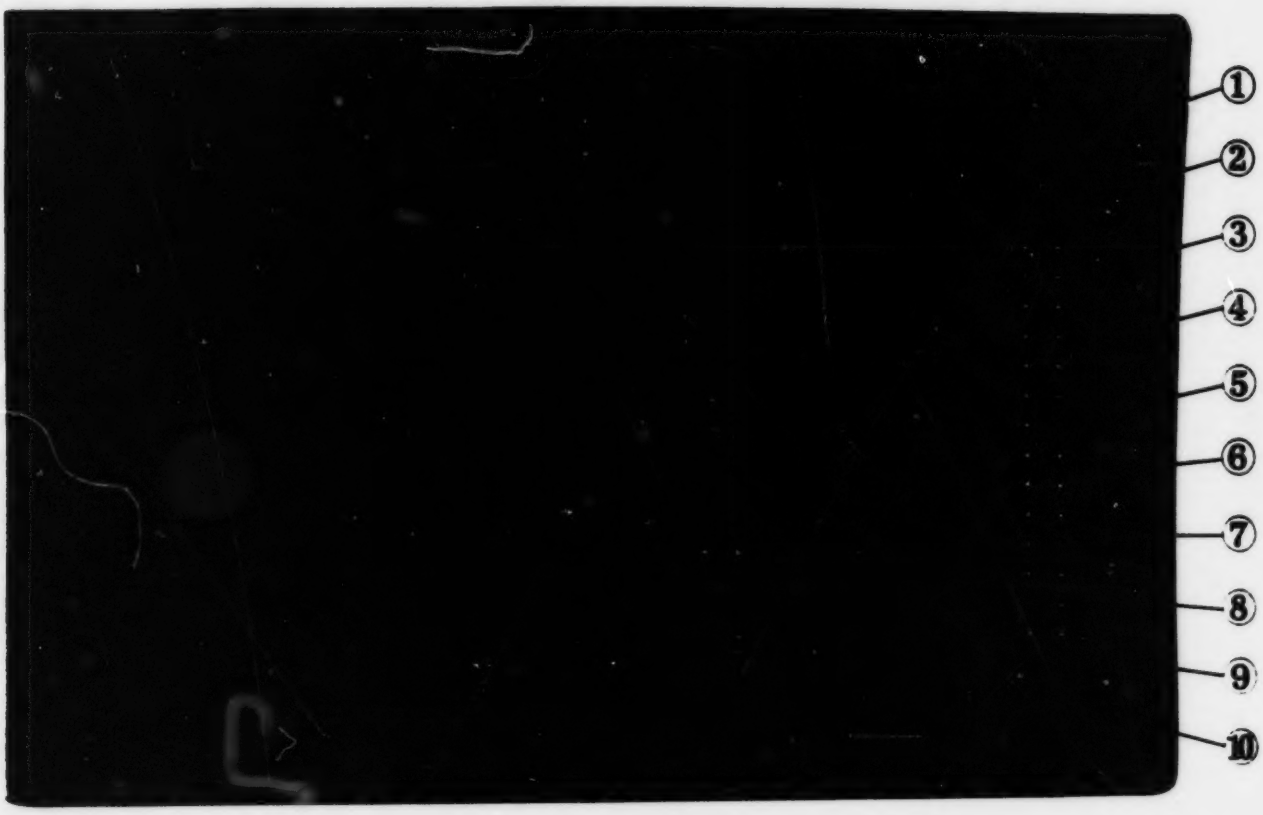
Touchkey electronic interswitching of up to 3 transceivers and display units.

Modular display consoles for operation while standing or sitting. Keyboard and CRT may be separated for custom installation.

Complete, computer-directed self-testing, performance monitoring, and trouble-shooting.

Interfaces with SNA-91 Integrated Bridge Display. Superimposes computer-generated navigation charts on the radar screen. The PATHFINDER/ST Radar and SNA-91 form the major components of an integrated bridge system.

ARPA Provides Electronic Tracking for up to 20 Targets, Automatic Acquisition, Exclusion Boundaries and Unique Trial Manoeuvres



Raytheon's leadership in ARPA began with the successful Raycas and Raypath ARPA. Now, 34 or 25-cm PATHFINDER/ST ARPA uses superior technology to provide performance that will maintain this leadership into the 21st century.

Accurate Information When it's Most Needed

Starting with its superior target detection system, PATHFINDER/ST signal processing ensures accurate tracking in noise and clutter. Precise tracking measurements, plus computer compensation of gyrocompass and speed errors, provide reliable collision assessment data during and following own-ship manouevres.

The PATHFINDER/ST ARPA automatically tracks and displays vectors and data for up to 20 targets, acquired manually or automatically. With auto-acquisition, up to 40 targets are monitored, while the 20 most dangerous are tracked. In addition to the standard ARPA features such as manual and automatic acquisition, north up/course up, trial manoeuvres, true/relative vector, and target trails, the PATHFINDER/ST ARPA includes an extensive training mode where internal scenarios permit full demonstration and use of all ARPA functions.

1 Readout of the two designated target tracks: Track 1, target north of own ship; Track 2, target east of own ship.

2 SAFE LIMITS - Enter safe limit CPA/TCPA for dangerous target warning. Depress appropriate menu switch, then enter the value using the front panel keypad.

3 VECTORS - Three menu switches for vector selection:
- True or relative vectors
- Standard or variable vector length
- Increase or decrease variable vector length.

True vectors are selected, with standard five-minute vector time for 6-nm range.

4 MODES - A status display showing all modes activated (Target Trails, Auto Acquisition, etc.) on the "SET" menu page.

5 AUTO DRIFT - Selector switch to select Auto Drift target and activate the Auto Drift function. In Auto Drift Mode, a fixed target is tracked to automatically calculate and compensate for speed errors (offset and drift).

6 DISPLAY - Selects Course-up Mode. The radar presentation is rotated to position Heading Line at 000 on the bearing scale.

7 FRONT PANEL "DISPLAY" SWITCH - Status matrix shows position of switches on front panel display section.

8 WARNINGS - Shows the current warning status: Dangerous Target, Speed Log Out, Auto Detection, etc.

9 DATA - Keyboard entry display shows the current value being entered from the keyboard.

10 MENU PAGE SELECTOR - Normal ARPA "page" currently selected. "SET" page selected when initial ARPA Mode changes are required. Other pages allocated for future options (such as Navigation Package).

Signal Processing and Improved Sensitivity Set New Standards for Target Detection and Clutter Suppression

Displaying Only Targets

With PATHFINDER / ST Radars, Raytheon engineers have come very close to the ultimate goal of displaying only targets.

Signal processing virtually eliminates noise, interference, and clutter.

Receiver Improvements

Receivers of the PATHFINDER / ST Radars have been noticeably improved over those used on other radars. Low-noise amplifiers have increased signal-to-noise levels by 3 to 4 dB (2 to 2.5 times). The high dynamic range of the logarithmic receiver ensures that target returns are faithfully reproduced under even the most severe clutter conditions.

To further fine-tune receiver performance, bandwidths are automatically varied to match the transmitted pulse lengths.

Signal Processor

The heart of the PATHFINDER / ST Radar is a multiple-stage Signal Processor. Years of research and development have resulted in this near-perfect target detector.

Many aspects of the received radar signal are analyzed by the processor to greatly improve target detection in noise and clutter.

The multi-level processing begins with the Detection Thresholder. It is here that receiver output signals are digitally detected. The front panel gain and clutter controls, in conjunction with programmed radar factors (eleven in all, defining the radar characteristics), are used by the Detection Thresholder to mathematically "model" the clutter levels. This ensures that a uniform "speckle," or noise density, is maintained on the display.

The output of the Detection Thresholder, consisting of targets, strong clutter peaks, and detected noise, is applied to the Pulse Processor. Radar returns for each transmit pulse are sampled at rates matched to the radar pulsewidth. The Pulse Processor performs binary detection, where a moving "window" samples groups of sequential returns, and the number of "hits" in the window is analyzed. If the number of hits meets the target detection requirements, the sample is saved; if not, it is rejected. This process eliminates some noise and prevents "straddling loss," i.e., the loss of targets between samples.

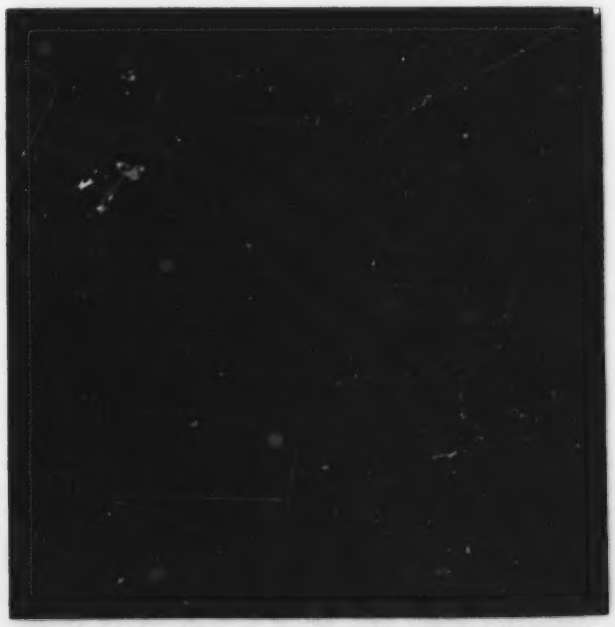
Each successive radar pulse transmission is sent on to the Beam Processor where beam detection takes place.

Beam Processor Eliminates Noise, Improves Detection

As the antenna beam scans across a target, the Beam Processor examines each "hit" or return from the targets. The number of hits in the antenna beam must satisfy the detection probability criteria before a target is passed to the Scan Converter. With this exclusive Raytheon process, radar interference and virtually all noise are removed. Tests have shown that Beam Processing improves detection by 3 dB or more over conventional PPI and raster display radars.

Raytheon's exclusive VLSI (Very Large Scale Integration) Scan Converter – the

With rain and sea clutter circuits turned OFF, PATHFINDER / ST ARPA display is shown on a ferry in The Sound between Denmark and Sweden, with wind exceeding 15 knots and sea state 3. Range is set at 6 nm. Gain is set at 40%. Note that sea clutter extends 1.8 to 2 miles from own ship, and ice floe belts appear 320° to 35°, with additional ice clutter scattered beyond the sea clutter 270° to 320°. Thick lines at 230° and 155° are RACONs.



With rain and sea clutter suppression circuits activated, the picture above is absolutely "clean." Sea and ice clutter are gone. All targets remain, and targets previously masked in clutter are clearly visible.

"Scan Converter on a Chip" – assembles the radar data into the proper format for the Field Processor and raster display memories. The Scan Converter has been designed to eliminate the "holes" and "overlap" found in some raster displays.

Scan-to-Scan Integration

The Field Processor is the final step of Raytheon's unique Signal Processing. Complete radar images are saved and compared with previous images so that consistent targets – those that correlate from scan to scan – are identified and separated from inconsistent targets, strong sea clutter and noise that escaped earlier processing.

The detection rules are simple: detected targets, no matter how weak in signal strength, are painted at bright levels. Noise and clutter, no matter how strong, are eliminated or, at most, painted dim.

The operation of the PATHFINDER / ST Radar is basically the same as that of any conventional radar. Gain and clutter controls are set for light, uniform noise speckle, but unlike conventional radars. Raytheon Signal Processing looks "deep" into the noise to find weak targets.

In side-by-side comparison tests between a PATHFINDER / ST Display and a conventional PPI display connected to the *same* receiver, it was found that the PATHFINDER / ST Radar displayed targets that were not detected by the conventional display. By combining a new high-performance receiver design and bright, high-resolution raster display with superior Raytheon Signal Processing, PATHFINDER / ST Radars provide unparalleled performance.

High-definition Daylight Displays

The number of pixels has been carefully chosen to provide optimum resolution at normal viewing distances, consistent with electron beam cross-section, or spot size. For both the 23 and 19-inch rectangular CRT's, the 768 x 1024 resolution provides pixels just slightly smaller than spot size... for the sharpest pictures with no visible separation between pixels.

Computerised Testing and Trouble-shooting

In addition to having the optional IMO-required, antenna-mounted performance monitors, Raytheon PATHFINDER / ST Radars are programmed for extensive self-testing and trouble-shooting diagnostics. Software provides menus for complete system testing. Memory, timers, input and output ports, switches, potentiometers... virtually every function can be tested. If a fault is detected in a circuit board, it is identified on the display for easy, plug-in replacement.

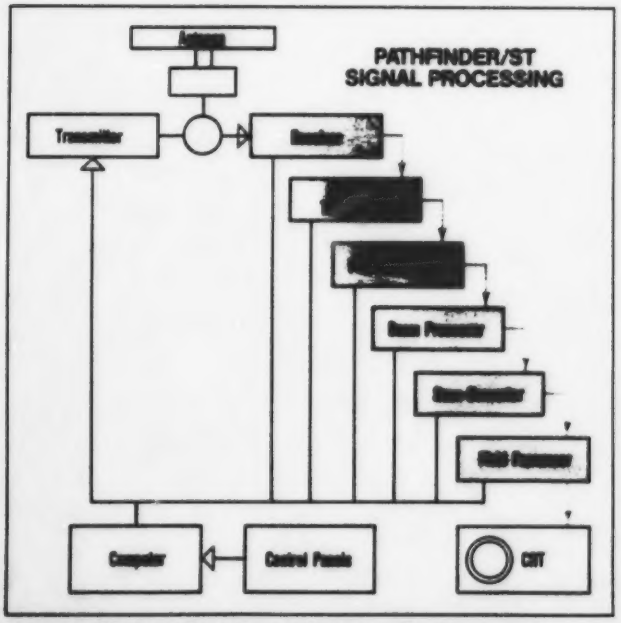
In the Self-test Mode, menus are also provided for initial entry and review of variable parameters such as antenna heights, beamwidths, power and pulse widths of transmitters... all of the data used to optimise clutter and noise suppression.

Simple, Low-cost Installation

Of all the large marine radars made to date, none can equal Raytheon PATHFINDER / ST units for economical, easy installation. For example, signal multiplexing greatly reduces the number of connections between displays and transceivers. The numerous switching and control signals that are required to operate the transceiver are compressed and multiplexed into a single, serial data stream requiring only a single wire pair. The receiver video, trigger, antenna position, and transceiver status are multiplexed into one composite video signal, which is carried on a single coaxial cable. With so few wires to connect, installation time and cost are greatly reduced. In addition, PATHFINDER / ST Radar dual systems do not need separate interswitch units.

The Models (M34) and (M25) PATHFINDER / ST Displays are designed so that the CRT display module, control panel, and electronics unit can "break away" for custom console design and installation.

And, finally, installation adjustments such as antenna bearing, heading marker, sweep delays (bank-pulling/pushing) and others can now be made with keyboard entries in only a few minutes. This eliminates the need to climb a mast to make these adjustments manually.



Unique multi-stage Signal Processing has evolved from years of Raytheon research. It uses Superior Technology to provide near-perfect target sensing and sharp, bright radar pictures virtually free of clutter.

Menu selection of comprehensive tests for trouble-shooting, fault isolation and initial set-up adjustments and parameters. Simple-to-use on-screen prompts and messages guide the user through each test sequence.

Raytheon PATHFINDER®/ST Radars for Every Need

Worldwide Approval

Raytheon PATHFINDER / ST Radars exceed all applicable commercial standards and comply with tough reliability testing requirements. They have also been built to meet the requirements of IMO and the national regulatory agencies of countries around the world.

"Up" or "Down" Transceivers

PATHFINDER / ST Radar 3-cm (X-band) and 10-cm (S-band) transceivers are mounted either in antenna pedestals (Up) or below (Down) in separate cabinets with waveguide feed.

Available transceivers are:
25 kW - X-band Up or Down
10 kW - S-band Up
30 kW - S-band Down
Available antennas are:
7 or 9-foot (213 or 274 cm) X-band.
12-foot (366 cm) S-band.

Electronically Interswitched, Multi-unit Systems

Raytheon PATHFINDER / ST Radar multi-unit systems, with two or three displays and transceivers, not only offer improved performance and reliability, but are considerably less costly to install and maintain. Gone is the cumbersome, multi-contact interswitch unit. In its place, a plug-in circuit board permits keyboard switching of up to three displays and transceivers... all with the assistance of an on-screen diagram that shows the system configuration in use.

The illustration below shows a typical dual system using 34-cm ARPA and 25-cm TM/EP displays with X-band "Up" and S-band "Down" transceivers. Simple interconnection between the two displays is all that's required. Any combination of displays may be selected: single or simultaneous 3 and 10-cm operation, 3 or 10-cm operation on both displays, simultaneous short and long range navigation... whatever the situation demands.

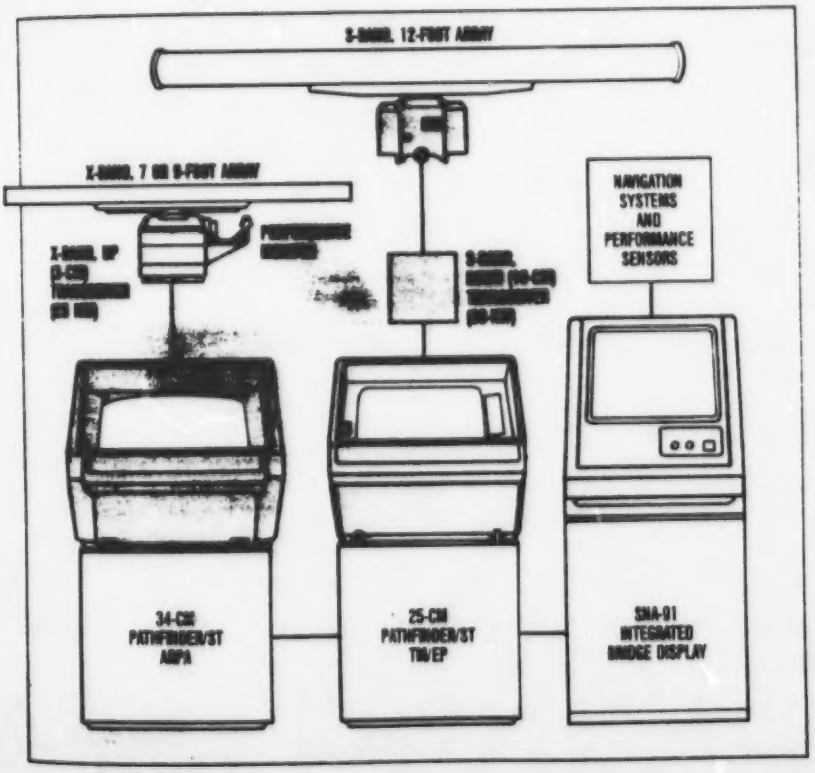
Integrated Bridge System

Raytheon, recognizing the trend towards centralized shipboard data processing and management (Integrated Bridge Systems), has designed significant interface capabilities into PATHFINDER / ST Radar Displays. The combination of the SNA-91 Integrated Bridge Display and the PATHFINDER / ST ARPA Display results in the most comprehensive and sophisticated Integrated Bridge System available today. The SNA-91 interfaces with the ship's navigation systems (Gyro, Log, Loran-C, Satnav, GPS, etc.), steering system and performance sensors, to provide complete navigation route planning, automatic steer-to-waypoint operation, ETA calculation, fuel consumption, weather, stability, engine data, etc.

Electronic charts, stored on floppy discs, are presented on the SNA-91 high-resolution color display, and selected chart information is transmitted to the PATHFINDER / ST ARPA.

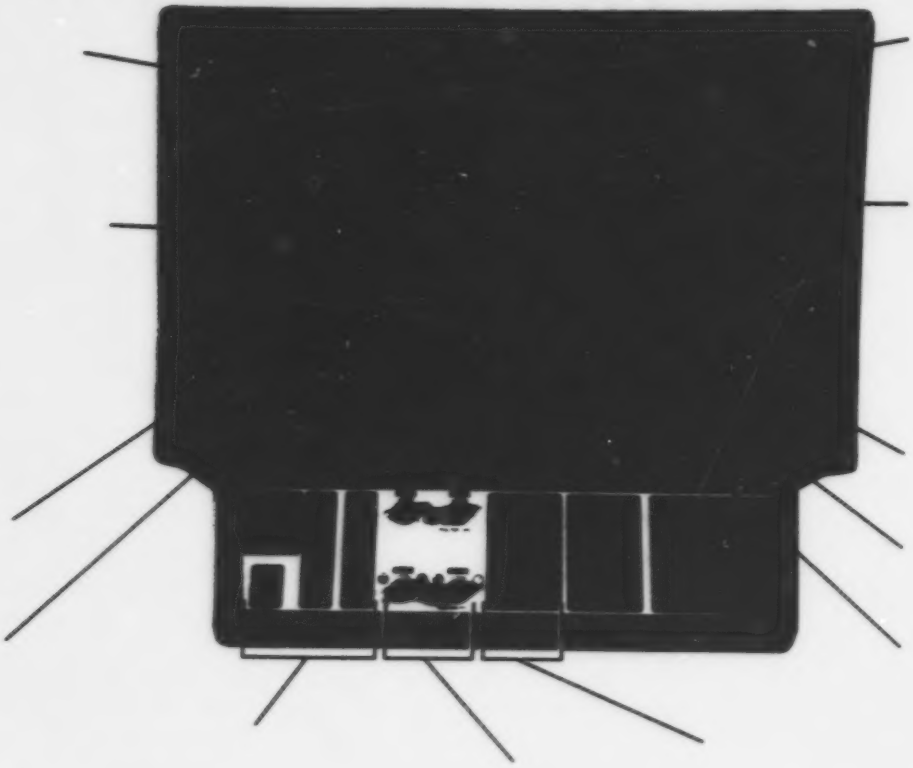
This provides the unique capability of simultaneous display of two charts of different sizes. The large area chart on the SNA-91 shows detailed navigation information with superimposed target tracks; the small area chart on the PATHFINDER / ST ARPA shows the composite radar picture with critical navigation data superimposed.

With Raytheon, the Integrated Bridge System of the future is available today.



CRT swings out for easy access. Virtually all electronics are on plug-in circuit boards. Aside from the number of circuit boards used, the basic True Motion/Electronic Plotting, and ARPA display units are identical.

Basic Display: Relative and True Motion, Electronic Plotting and Trial Manoeuvres



The Electronic Plotting feature permits easy target plotting that is more accurate than conventional reflection plotter methods. A total of six targets may be plotted simultaneously, and the calculated data for any two selected targets are displayed in the upper right corner of the display.

The Electronic Plotting procedure has been designed to closely follow the typical reflection plotter operation. To begin, the Plot Mode is selected and the trackball is the used to position the plot mark over the target of interest. At this point, the display processor "remembers" the plot start time. Now the trackball is free for other operations. When sufficient time has passed (three minutes, six minutes, etc.) for the target to move away from the first plot mark, the Plot Mode is entered again and the trackball used to position a second plot mark over the target. Once the second mark is entered, a vector (true or relative) appears over the target and will follow the target based on the plotted speed and course. A total of up to four plot marks may be entered for each target. When relative vectors are selected, they can be extended to show the CPA on the radar display. When a readout of target data is required, a plotted target can be designated with the trackball, and the data is presented in the upper right corner of the display.

A Trial Manoeuvre Mode is available from the "menu". When selected, plotting calculations are changed to reflect the trial course and/or speed entered.

The above display illustrates the Electronic Plotting capabilities of PATHFINDER / ST Radars.

The display is set to 6-nm range, TM Mode, north up, and offset 70% to the west. The target to the north has been plotted for three plot intervals (shown by the 3 triangle symbols) and is designated No. 1 (the designate symbol with the number "1"). The designated target data, the upper right display, shows target No. 1 is 4.3 nm, bearing 020° from own ship, and is on a course of 258° with a speed of 7.8 knots. Calculated CPA is 4.5 nm with three minutes to CPA (TCPA).

True vectors are selected, with an eight-minute vector length (selected from the menu).

A second target has been designated. This target, 6 nm northeast of own ship's position, has been plotted for four plot intervals, and the designate symbol shows the number "2." The corresponding data table for this target shows a course of 142°, speed 15.3 knots, and the CPA is 4.5 nm with 28 minutes to go (TCPA).

A third plotted target, 2.5 nm east-northeast of own ship, has a true vector that indicates the vessel is on a parallel course with own ship, and the vector length is longer than own ship's vector. Therefore, this target is pulling away. If data readout is required for this target, it can be designated.

The dashed line that crosses the ship's heading marker, 6 nm ahead of own ship, is the NAVLINE. It can be used to measure range and bearing between two points on the radar display. The bearing and range of the NAVLINE are displayed in the upper right corner of the PPI display.

Specifications

	X-Band		S-Band	
	MTR Up	MTR Down	MTR Up	MTR Down
Peak Power	25 kW		10 kW	30 kW
Frequency	9410 ± 30 MHz		3050 ± 30 MHz	
Wavelength	3.2 cm		10 cm	
Receiver IF	60 MHz		60 MHz	
Receiver Noise	7.5 dB		5.7 dB	5.1 dB
Pulse Widths (μsec)	0.08	0.25	0.75	1.0
Pulse Repetition Frequency (PRF)	3000	2000	1000	750
Receiver Bandwidths (MHz)	20	6	4	4
Height		61 cm (24")		61.5 cm (24.2")
Width		61 cm (24")		61.5 cm (24.2")
Depth		30 cm (12")		41 cm (16.1")
Weight		46 kg (101 lbs.)		57 kg (126 lbs.)
Standard Compass Safe Distance		4.4 m (14½ feet)		4.4 m (14½ feet)
Steering Compass Safe Distance		2.7 m (9 feet)		2.7 m (9 feet)

	X-Band		S-Band
	7-Foot (2.1 m)	9-Foot (2.7 m)	12-Foot (3.7 m)
Horizontal Beamwidth	1.0°	0.85°	1.9°
Vertical Beamwidth	25°	25°	30°
Horizontal Sidelobes	–32 dB	–32 dB	–32 dB
Gain	28.5 dB	29.2 dB	28 dB
Polarization	Horizontal		
Rotation RPM (50/60 Hz)	22 / 26		
Swing Circle	2.29 m (7.6')	2.82 m (9.3')	3.96 m (13')
Height	61 cm (24")	61 cm (24")	88 cm (34.6")
Weight (MTR Down)	65.5 kg (144 lbs.)	67 kg (148 lbs.)	169 kg (373 lbs.)
Weight (MTR Up)	71.5 kg (158 lbs.)	73 kg (161 lbs.)	175 kg (386 lbs.)

	25 cm									
CRT size (diagonal)	48.3 cm (19")						58.4 cm (23")			
PPI Diameter	25 cm (9.8")						34 cm (13.4")			
IMO Equivalent	12" Diam. CRT						16" Diam. CRT			
CRT Phosphor	Green (P-39)									
Resolution	768 x 1024 lines (786,432 pixels)									
Range Scales (nm)	¼	½	¾	1½	3	6	12	24	48	96
Range Rings (nm)	⅛	¼	¼	¼	½	1	2	4	8	16
Minimum Range	25 m (27 yards)									
Range Resolution	0.3% or 3.6 m (4 yards), whichever is greater									
Range Ring Accuracy	0.3% or 6.4 m (7 yards), whichever is greater									
Bearing Accuracy	1°									
Bearing Resolution	0.3°									
Cursor Bearing Readout Resolution	0.01 nm up to 10 nm and 0.1 nm up to 96 nm									
Height	115 cm (45")						119 cm (47")			
Width	62 cm (24")						68 cm (27")			
Depth	68 cm (27")						76 cm (30")			
Weight	77 kg (170 lbs.)						98 kg (216 lbs.)			
Standard Compass Safe Distance	3.1 m (10 feet)									
Steering Compass Safe Distance	1.8 m (6 feet)									

Raytheon Product Support

Raytheon maintains an extensive service and spare parts organisation with facilities around the world. Technical service groups constantly analyze field service support to improve equipment reliability, service quality, and spare parts support for ships at sea. For further details, please ask for the latest Raytheon Service Station list.

Nav Data Readouts: Heading, course, speed, set and drift
SNA-91 Navigation: Interfaces for SNA-91 Color CRT Navigation System to receive computer nav charts to be superimposed on radar video.
Self-testing: Computer menus for complete system diagnostics and trouble-shooting
Interswitching: Touch-key, electronic interswitching of up to 3 display and transceiver units
Installation Alignment: Antenna bearing, zero range, etc. by keyboard entry
Performance Monitor: Optional antenna-mounted unit meets IMO requirements with on-screen warnings
ARPA: 34 or 25-cm PPI with automatic tracking of up to 40 targets with vectors and read-outs (course, speed, bearing, CPA, and TCPA) for most dangerous 20. Auto and manual acquisition areas. Trial manoeuvres, nav lines, etc. Exceeds IMO requirements
TM/EP: 34 or 25-cm PPI with true and relative displays. Electronic Plotting: course, speed, bearing, CPA, and TCPA for two selected targets. Plot marks and vectors for targets. Trial manoeuvres, nav lines, etc.
[illegible]: Standard pulse length is [illegible] with range [illegible] meet shorter or [illegible] pulse
[illegible] on-screen [illegible] and bearing [illegible] positioning [illegible] readouts
[illegible] Manual sea and [illegible] automatic [illegible] pulse width [illegible] height, speed, etc

RAYTHEON MARINE COMPANY
[illegible]
[illegible] NH 03801 USA
[illegible]
[illegible]
FAX (603-881-4756

RAYTHEON MARINE
SALES AND SERVICE COMPANY
Silkegade 6
DK-2300 Copenhagen S Denmark
45-1-570611
Telex (855) - 31473
FAX 45-15-74077

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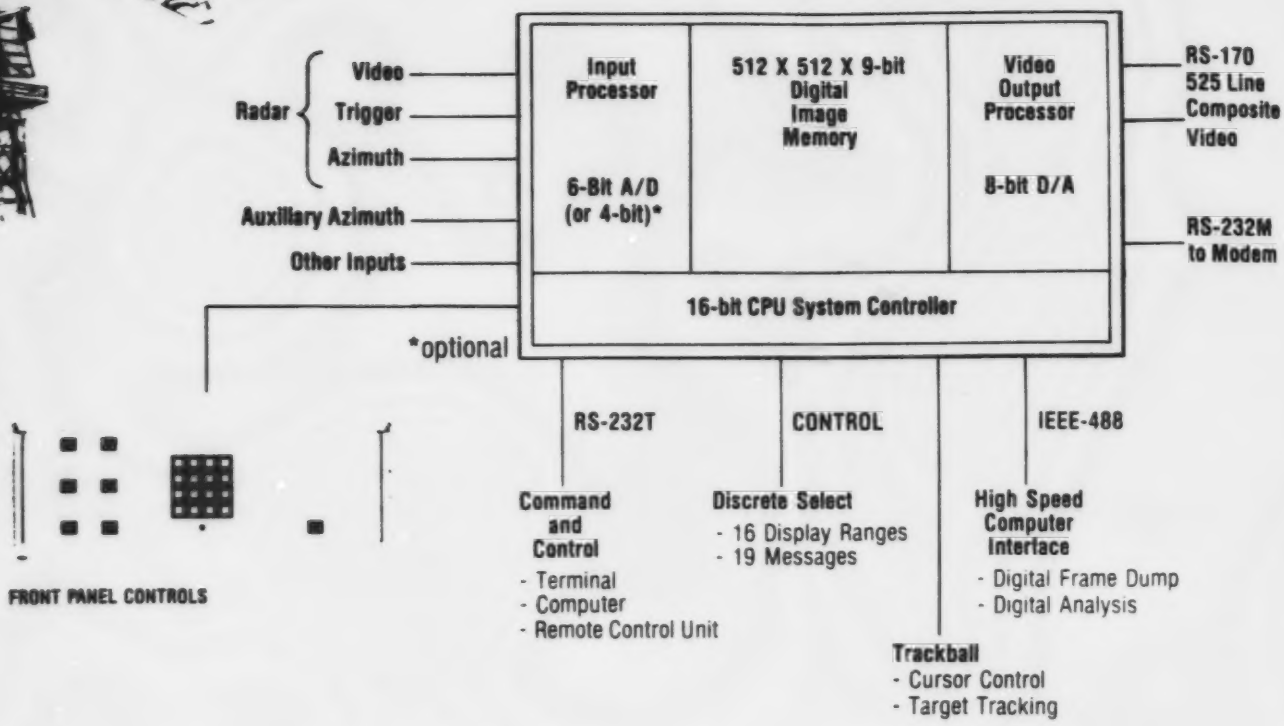
FOLSOM RESERACH INCORPORATED

RADAR SCAN CONVERTER and DIGITAL IMAGE PROCESSOR

FRI FOLSON RESEARCH INCORPORATED

Model 8342 Radar

The Basic System



Applications

Vessel traffic Monitoring
Enables tracking of maritime targets with any radar. Provides automatic target plotting, overlay maps, EBL, VRM, optional alarm functions.

Air Traffic Monitoring
Real-time display of aircraft flight paths with ability to track limited number of targets.

Target History Recording
Provides high definition video recording of all targets detected by any radar. With frame freeze feature 24 hours of radar traffic history can be stored in about 20 minutes of video tape.

Radar Digital Display Processor
Real-time digitizating of radar video into digital image memory with output in analog video format. **Optional** digital video output to host data bus.

PPI Console Upgrade
Direct low-cost replacement for PPI display consoles with significant improvement in target presentation and improved operator proficiency.

Radar-to-Computer Interface
Direct connection of scan converted digital radar data to host computer via RS-232 or IEEE-488 ports.

Radar Simulator
Computer generated analog or digital radar data can be input to 8342 to create raster video output to simulate cockpit or console radar displays.

Configuration Options

Standard (8342)
19" rack mount. 10 ¼" H x 19" D. 38 lbs.

Portable (8342P)
Watertight transit case 9" x 20" x 24". 60 lbs.

Console
Single operator console with 15" display, system control unit, trackball, provisions for scan converter(s) and auxiliary processing unit.

1 ATR case
Same or smaller modules, upgraded power supply, wider operating environment.

Digital Scan Converter

Performance Features

Radar Video Digitizer
6-bit A/D flash converter provides 64 digital levels of radar signal for 512 pixel vector. Input sampled at 20 MHz. **Optional** 65 MHz with 4-bit A/D.

Digital Image Memory
512x512x9-bits, 6-bits for radar video and 3 1-bit overlay planes. Option: 5,1,1,1,1 or 3,3,1,1, or ? **Optional** frame-to-frame averaging to reduce noise and random signal returns. **Optional** Digital MTI with dual memory partitions. One converted radar scan is frozen in memory then subtracted in whole or part from succeeding scans to reduce clutter and highlight moving targets.

16-bit system controller
An 8086 based system controller module provides 2 serial RS-232 and one parallel IEEE-488 ports and 1 16-bit control port. Module also controls input, fade and output Look-up Tables. **Optional** 8087 co-processor provides 32-bit floating point computations for tracking, plotting, or data analysis.

Map/Graphic Overlays
Multiple overlay maps can be stored in EPROMs or can be downloaded from an external system into RAM. Maps can be designed and installed by user after 3-day training class. Brightness for each overlay can be controlled separately from radar video.

Messages & Annotations
Up to 19 message blocks of 40 characters each can be user programmed in ROM or downloaded in RAM for display on one of the overlay planes. Status block includes clock/calendar set by user.

Programmable Fade
Fade can be operator controlled to provide target trail history for up to 30 minutes or as little as 3 seconds.

Display Offset
Operator can locate radar anywhere in active video for up to 100% offset and increase display resolution.

Input Signal Threshold
Selectable threshold levels can be set via Input Look-up Table to reduce effects of ground clutter and improve target presentation while at maximum radar gain.

Freeze Frame
Freezes scan converted image in display memory. Digital image frame can then be output via IEEE-488 or RS232 data ports at 600 kHz or 9600 Hz respectively.

Remote Display
Scan converted radar images or data can be transmitted by modems over telephone data lines at rates of 300 to 9600 baud to a second 8342 unit.

Computer Interface
Scan converted digital image data can be extracted by and sent to remote computer at 600 kHz rate via IEEE-488 port. **Optional** rack mounted Data Interface and Data Measurement Unit.

Remote Control
All scan converter control and display functions can be done by remote control via the RS-232T Terminal Port or by a Remote Control Unit connected to the control port.

Options

Remote Display System
Using 2 model 8342 units, 2 modems and one telephone data line, radar image or radar data can be transmitted any distance via the serial RS-232 port at selectable baud rates. Standard full frame transmission in about 30 seconds at 9600 baud; faster transmit options are available.

Radar Target Tracking and Plotting
Using the Remote Display System, a tracking and plotting option is available which enables tracking of up to 25 maritime targets. An operator initiates the tracks and the system auto tracks, providing immediate updates of target plot positions to remote display unit. **Optional** automatic target acquisition and tracking.

Range Height Indicator (RHI)
For an elevation scan, input unit converts, computes and presents targets in a range-height format with presentation corrected for earth curvature and site elevation. Moveable cursor displays range and height to targets. Also includes standard PPI and PPI offset modes.

Optional Video Output
- CCIR 625 line, 50 Hz, monochrome
- RGB (RS-170 or CCIR) with NTSC composite color option.
- Digital image in 640 x 480 or 1024 x 1024 format.

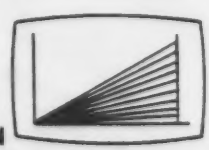
Output Display Modes

Standard Display Modes

PPI

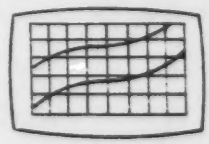
100% OFFSET

Optional Display Modes



RHI SCAN

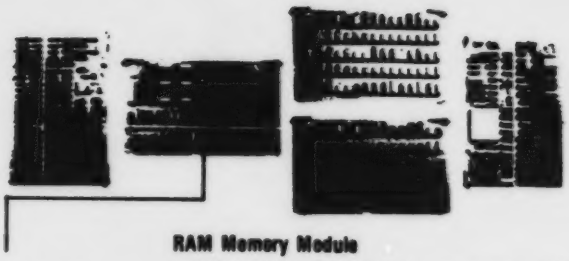
EXPANDED OFFSET



Functional Common Modules

Input Processor Module

Accepts raw radar video, trigger video and azimuth data from any pulsed radar with a PRF up to 4 kHz. A/D converter is 6-bit. A look-up table is provided for application of algorithms to input video.



Video Output Processor Module

An 8-bit D/A converter which transforms digital image data to two isolated, RS-170 composite raster video outputs in a 525 line, 2:1 interlaced format at a 30 Hz refresh. Module contains software controllable look-up table for image processing functions.

CPU System Controller Module

The System Controller provides master control and system interface for all internal and external functions. External I/O and control is accomplished via two RS-232 and one IEEE-488 ports. An 8086 based CPU controls look-up tables in both the input and output processor modules. Provisions are also included for an 8087 arithmetic co-processor.

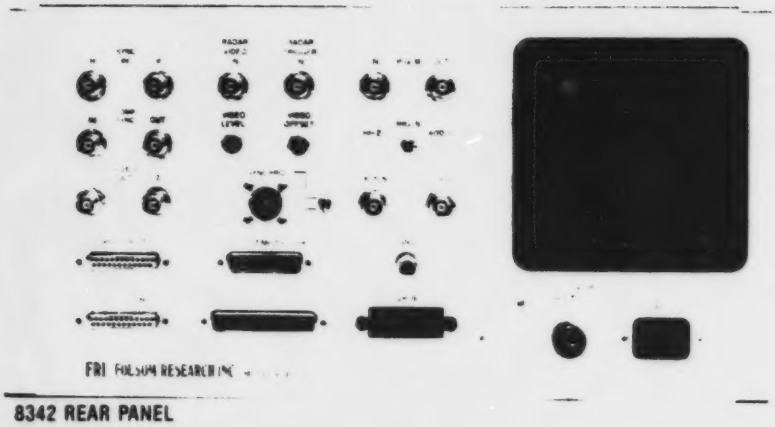
RAM Memory Module

A 512 x 512 x 9-bit image memory on two PCB's. One 1-bit memory plane is always dedicated to overlay and annotation for graphics, symbols, maps, cursors, messages, etc. Image memory can be software controlled to configurations such as:

One 6-bit image memory with three overlay planes (standard configuration for programmable "fade and trail" plus 3 map overlays).

Two 4-bit image memories with one overlay (for image integration or subtraction, to create MTI type of display). (Option)

Specifications



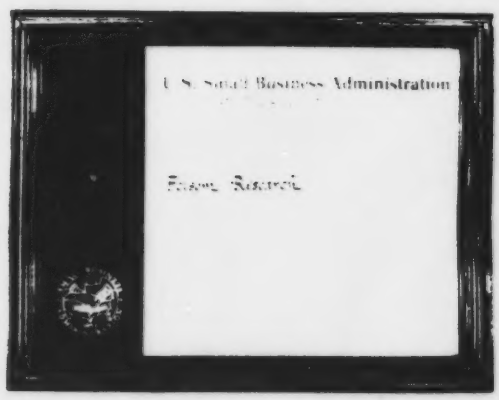
8342 REAR PANEL

INPUTS

Radar Video:	1-5 volts peak, gnd reference DC to 5 MHz
Radar Trigger:	5 volts TTL level (25 volts max) PRF to 4000
Azimuth	Synchro, 5-wire; or 12-bit parallel, TTL; or Azimuth Change Pulses (ACP), 4096/rev with North or Heading Ref Pulse (NRP)
Size:	19" rack mount, 10¼" H. x 20" D.
Weight:	39 lbs.
Temperature:	0°C—45°C

Other Products & Capabilities

- Radar Display Simulators
- High Line Rate Video Scan Converters (Model 8430)
- 1024 line RGB to 525 line NTSC/RGB Scan Converter
- X-Y Stroke-to-Raster Scan Converter (Model 8450)
- IR Line Scanner to Raster Video Scan Converter
- Digital and Video Display Processors
- 1024x1024x16-bit Video Scan Converter



FRI **FOLSOM RESEARCH INCORPORATED**

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1286-1000

RACAL MARINE RADAR LIMITED

RACAL DECCA

DEEP SEA COLOUR RADARS

RM2090BT, RM2070BT

Racal Marine Radar

RACAL

Welcome to the new world of colour in professional deep sea radars.

These new Racal-Decca BRIGHT-TRACK radars not only lead the world in the effective use of colour but are designed to meet in full international type approval requirements. They are suitable for installation in vessels up to 10,000 tons as primary radars, or in vessels of any size as second sets.

Earlier, these special BRIGHT-TRACK colour techniques, unique to Racal-Decca equipment, had been available only to small boat and coastal vessel operators.

Now, after careful development and sea trials, the 2090 and 2070 BT radars make colour available for large, ocean-going ships where strict international conventions and regulations apply.

The new radars offer:

Professional azimuth-stabilised RM presentation – in colour, with the unique Racal-Decca BRIGHT-TRACK presentation – optimised for day and night use.

Clear identification of ship targets, land, track history and generated information (VRM, EBL, parallel index lines, etc) providing instant visual analysis of traffic situation.

Self-evident threat assessment from well-defined, easily-seen RM tracks presented at the touch of a button.

Excellent performance in clutter. Scan to scan correlation, switchable CLEARSCAN, automatic sensitivity control and operator control of track history (afterglow) enable high gain to be maintained in clutter without loss of small targets.

Two electronic parallel index lines can be set up for selected passing distances and directions, [illegible] in position. Alternatively, [illegible] can be set on approaching echoes and rotated to measure relative [illegible] with rapid indication of CPA.

Choice of day or night colour coding

Switchable day or night colour coding which minimises eye strain and limits background light at night, permitting easy viewing from several metres under all ambient lighting conditions. Master, Officer of the Watch and Pilot simultaneously can view – but more importantly comprehend – the display.

Guard [illegible] alert.

Large 20 inch diagonal [illegible] (12 inch p.p.i. equivalent) with [illegible] scales from ¼ nm to 96 nm.

Choice of 10 cm 30 kW, 3 cm 25 kW or 3 cm 10 kW transceivers.

Plus the worldwide support of the Racal-Decca Service Organisation.

So Why Choose BRIGHT-TRACK?

It is already well-acknowledged that the Racal-Decca BRIGHT-TRACK colour system makes the most effective use of colour in the radar presentation. Unlike monochrome rasterscan displays, it is not simply a daylight viewing adaptation of conventional p.p.i. techniques. Nor is it based on the echo sounder principle employed by some multi-colour sets, whereby colour is used to denote echo strength (e.g. red – strong, green – weak). This is not only a needless distraction, actually increasing stress on the bridge, but can be positively confusing and misleading – confusing in bad sea clutter when echo strengths can change from scan to scan; misleading when, for example, a supertanker dropping astern is shown as a priority target in red, while a hovercraft approaching fast, but at some distance on the starboard bow, might be in low priority green.

The Racal-Decca BRIGHT-TRACK presentation, carefully optimised to improve perceptibility by day or night and thus to reduce strain, uses colour as simply as possible to differentiate basic radar information, past history and reference data:

- Blue background (Black at night).
- Low intensity brown for single sweep echoes.
- Traditional yellow/amber for correlated radar echoes (Targets and land).
- Black for correlated echo tracks (Blue at night).
- White for navigational information (VRM, EBL, Ships head, bearing scale etc) (Green at night).

The use of Digital Scan Conversion (DSC) techniques provides a steady picture. The 20 inch screen (with 12 inch p.p.i. in the centre and navigational/ancillary information displayed a

'CLEARSCAN' with video correlation

In addition to their unique colour displays, the 2090 and 2070 BT radars have logarithmic receivers and therefore all the advantages of 'CLEARSCAN' video processing, including automatic clutter suppression and echo stretching or enhancement. Scan to scan correlation further improves performance in clutter. The first paint of any target appears in low perceptive brown with the yellow/amber colour being established only at the second scan, thus minimising transient interference and clutter returns without prejudice to genuine targets.

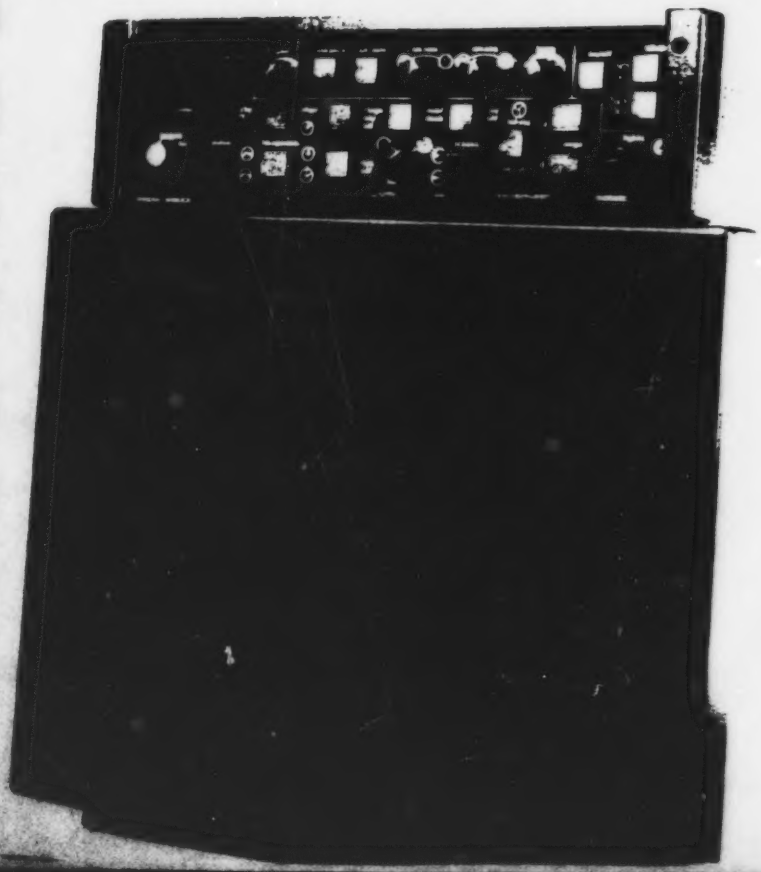
Designed to Deep Sea Type-Approval Requirements
The 2090 and 2070 BT radars, with the effective p.p.i. viewing area of a standard 12 inch display are designed to satisfy IMO carriage requirements as primary radars for vessels up to 10,000 tons. They can, of course, be fitted in conjunction with a 16 inch ARPA radar in vessels of any size.

The 2090 BT (3 cm) and 2090 S BT (10 cm) are fully interswitchable with other radars in the Racal-Decca Master range of deep sea radars.

the four corners) is refreshed 30 times a second to provide not only a 'daylight viewing' picture, but one that is always displayed and assessed at a glance.

The navigational and status information displayed includes: ship's head, range scale, range rings, EBL and VRM readout, parallel index direction, pulse length, standby, anti-clutter auto, track direction in minutes, stabilisation and echo enhance.

Echo trails are not simply a line of past plots but are simulations of conventional afterglow tracks with realistic timed decay according to range scale, giving an excellent indication of the target's relative speed as well as course.



Equipment Details

The Display comprises a control unit and a viewing unit which may be installed in a number of configurations to provide the most convenient arrangement on the bridge. Where necessary these two units can be separated by 5 metres.

Conventional slave displays can be added. Furthermore, the new 12 inch colour display can be used as a slave with earlier Racal-Decca radars, via a suitable slave junction box.

Secondary viewing units with no controls can also be added to the installation to give copies of the picture seen on the primary unit. These units require a local AC mains input and are located within 50 metres cable run from the primary unit.

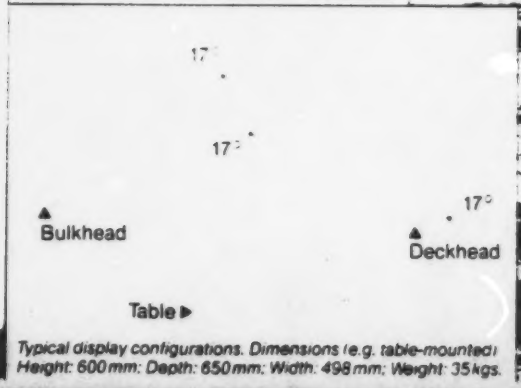
Transceivers
For 3 cm radars, a choice of 10 kW (RM 2070 BT) and 25 kW (RM 2090 BT) is available. For 10 cm (RM-S 2090 BT), a 30 kW unit is supplied. These transceivers have been most carefully designed for prolonged, trouble-free operation. The high output power results in excellent range performance. This is particularly true when the transceiver is incorporated in the scanner unit so that all wave guide losses are eliminated. In the case of 25 kW and 30 kW units, an optional bulkhead mounted transceiver is available where installation below is preferred.

The 3 cm microwave design incorporates a 3-port circulator and a Gunn oscillator. Close range performance of exceptional quality is provided. The 30 kW, 10 cm unit employs an advanced low noise front end giving a very low noise factor of approximately 6 dB. This unit is associated with a traditional branch duplexer with coaxial output.

Three pulse lengths provide optimum characteristics at the longer and shorter ranges with operator choice of pulse length on intermediate scales. Cancellation of second trace echoes by a combination of trigger frequency filter and interference suppression, eliminates the display of false echoes of this type.

Scanner Units
A choice of slotted waveguide aerials is available as follows:

for RM 2070 BT – choice of 3 or 6 ft aperture
for RM 2090 BT – choice of 6 or 9 ft aperture
for RM-S 2090 BT – 12 ft aperture



Typical display configurations. Dimensions (e.g. table-mounted) Height: 600 mm; Depth: 650 mm; Width: 498 mm; Weight: 35 kgs.

SPECIFICATIONS –
Racal-Decca 12 inch Colour DSC Radars

3 cm Radars

RM 2070/4 BT	10 kW transceiver, 4 foot scanner
RM 2070/6 BT	10 kW transceiver, 6 foot scanner
RM 2080/6 BT	25 kW transceiver, 6 foot scanner
RM 2080/9 BT	25 kW transceiver, 9 foot scanner

10 cm Radars

RM-S 2090 BT	30 kW transceiver, 12 foot scanner

Antenna Systems:

	3 cm			10 cm
Aperture	4 ft (1.2m)	6 ft (1.8m)	9 ft (2.7m)	12 ft (3.6m)
Horizontal Beam-width (-3dB)	2°	1.3°	0.8°	2°
Vertical Beam-width (-3dB)	27°	27°	27°	30°
Sidelobes within 10° of beam	-23dB	-25dB	-25dB	-23dB
Sidelobes outside 10° of beam	-30dB	-30dB	-32dB	-30dB
Gain	26dB	28dB	31dB	26dB
Polarisation	Horizontal	Horizontal	Horizontal	Horizontal
Rotation	25 rpm	25 rpm	25 rpm	22 – 26 rpm
Limiting relative wind speed	100 knots	100 knots	100 knots	100 knots

Transmitter Characteristics

Magnetron peak power – 3 cm : 10 or 25 kW nominal
10 cm : 30 kW nominal

Pulse length prf – 10 kW, 3 cm transmitter
0.08 μsec/2400 Hz;
0.3 μsec/1200 Hz; 1 μsec/600 Hz
– 25 kW, 3 cm and 30 kW, 10 cm transmitters
0.05 μsec/1300 Hz;
0.25 μsec/1300 Hz; 1 μsec/650 Hz

Pulse Generator – Solid-state with pulse forming network driving a magnetron

Configuration
– 10 kW Tx/Rx integral with scanner gearbox unit
– 25kW Tx/Rx either integral with scanner gearbox or separately housed for bulkhead installation
– 30 kW Tx/Rx either integral with scanner gearbox or separately housed for bulkhead installation

Receiver Characteristics

Type : Logarithmic with balanced mixer

Tuning : Manual with indicator on viewing unit

IF : Centred on 60 MHz

IF Bandwidth nominal : 20 MHz on short pulse, 4MHz on medium and long pulse

Noise factor : 10 and 25 kW transceivers, 10dB nominal
30 kW 10 cm transceiver, 6dB nominal

Power Supplies

Nominal input : 115v or 230v ±10%, 50/60 Hz, single phase

Consumption :

with 10 kW Tx/Rx	250 W
with 25 kW Tx/Rx	300 W
with 30 kW 10 cm Tx/Rx	300 W

NOTE:- In the case of the 10 cm radar the aerial gearbox is powered directly from ships mains (consumption 370 W). Aerial rotation motors are available as follows:-

Single phase: 110v or 220v, 50/60 Hz
Three phase: 110v, 240v or 440v, 50/60 Hz

Ancillary Equipment

– 3 cm or 10 cm performance monitor systems.
– Secondary viewing units providing copy of radar picture on primary viewing unit. A number of these secondary units may be installed on a daisy chain principle at remote locations up to a total of 50m cable run from the Control Unit.

Operational Specification

RANGE SCALE (in nautical miles)	*RANGE RINGS* (in nautical miles)	*PULSE LENGTH*
0.25	0.05	Short
0.5	0.1	Short or medium
0.75	0.25	Short or medium
1.5	0.25	Short or medium
3.0	0.5	Medium or long
6.0	1	Medium or long
12.0	2	Medium or long
24.0	4	long
48.0	8	long
96.0	16	long

Range and Bearing

Minimum Range : 30 m on 10 m² target with short pulse, 4.5 m aerial height and 4.5 m waveguide/coax run.

Range Discrimination : 35 m on 0.75 nm scale.

Range Ring Accuracy : 1% of maximum of scale in use or 25 m, whichever greater.

Variable Range Marker : Variable from 00.01 to 96 nm displayed on tube face. Accuracy better than 1% of range scale in use or 25 m, whichever greater.

Bearing Scale : Electronically generated. 1°, 5° and 10° marks labelled every 10° from 0°-360°.

Electronic Bearing Line (EBL) : Variable in ½° increments. Accuracy ±1°. Centered origin.

Parallel Index Lines : Two are provided. Passing distance and direction can be pre-set and locked.

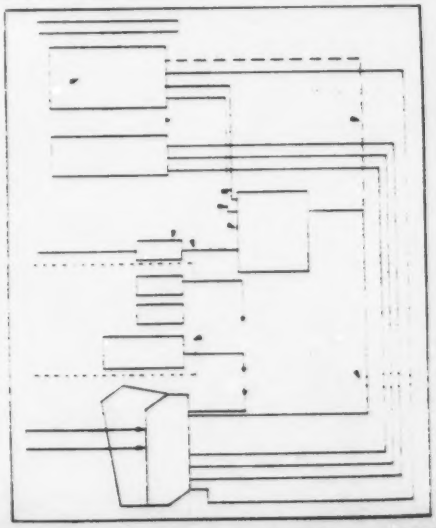
Azimuth Stabilization : Integral system supplied as standard.

Display

Viewing Unit : 20 inch (508 mm) diagonal TV type, (625 line, 60 Hz raster) medium resolution colour tube providing IMO nominal 12 inch display. Total picture size 768 x 576 pixels. Radar picture size 504 x 504 pixels.

Control Unit : Carries all controls for display and radar system, power unit, interface circuits and the scan conversion logic circuits. May be installed integral with the viewing unit or separated by a 5m cable.

Controls : On-Off · Standby · Pulse Length · Stabilise · Range Select · VRM · EBL · Parallel Index · HM Suppress · Anti-Clutter Rain · Anti-Clutter Sea · Range Rings · Gain · Brilliance · Track History On-Off and Short · Long · Panel Dim · Tuning · Align · Colour Blue · Black · Anti-Clutter Auto · Tube Brill · Enhance



Racal Marine Radar Limited

We reserve the right to vary in detail from the descriptions and specifications contained in this brochure.

SPERRY CORPORATION

The Sperry RASCAR

Raster Scan Radar & A.R.P.A.

Meet the "RASCAR" (RASterscan Collision Avoidance Radar)

Sperry proudly unveils a major advance in marine Radar and Collision Avoidance technology. Our concept is so new, it warrants coining a new equipment name.

The RASCAR series provides a wide range of radar systems with an integral ARPA as standard. Each system incorporates a revolutionary "Touch Screen" approach to the man machine interface and employs a high resolution raster scan display in monochrome or color.

Our RASCAR approach is not just technology for technology's sake. The approach offers clear major benefits to the customer and operator, including:

- major improvements in human engineering
- a true daylight viewable display
- low acquisition costs
- the highest performance specification with all previously optional features NOW STANDARD AT THE SAME PRICE:
  ARPA
  True Motion
  Azimuth Stabilization
  Off Centering
  Free-Footed Electronic Bearing Line
  Radar Interference Canceller
- low cost of installation
  uses standard shipyard cables
  quick connect terminal strips
  suppiy voltage conversions a snap
- low cost of ownership
  complete system Built in Test Equipment (BITE) allows repair on board by modular replacement and does not require services of expensive technicians.

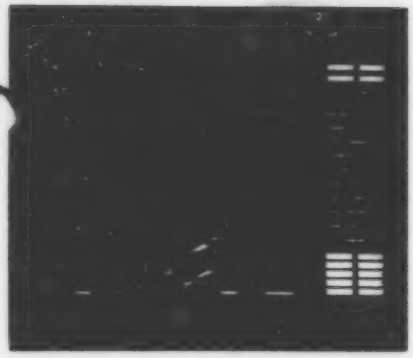
The TRIDENT Concept and RASCAR

Current marine industry trends clearly demonstrate that a new approach to electronics is underway. The need for ship operators to reduce operating costs yet increase operating efficiency is paramount. Newly designed ships must operate safely and efficiently with significant reductions in manning levels. Older ships must incorporate as much of the new philosophies as they can, since an existing vessel may not be designed to be operated at todays' reduced manning levels.

In this environment, Sperry has taken a hard look at how to best serve the marine community of the 1990s. Our wide product range and our traditional roots in the marine and data processing industries have given us the unique opportunity to design equipment that can be integrated both electronically and aesthetically from a single stand-alone RASCAR display to a fully integrated Fleet Management System linked to the home office by SATCOM. Each module in the system is based on common hardware and software standards and the exchange of information between the modules has been optimized by this Product Standardization and Integration (PSI). Finally each module has been carefully packaged to ensure that it can be mechanically mated with other modules to build a bridge control console that is aesthetically pleasing and ergonomically advanced, yet responsive to a wide variety of customer layout preferences.

The TRIDENT philosophy of product standarization and integration is therefore a wide reaching and fundamental change in the way the electronics manufacturer meets the market needs. It is designed to benefit the customer, and high technology is used only to make benefits possible.

The RASCAR series is just one aspect of Sperry's totally new approach to marine electronics and has been designed to not only give you the best radar and ARPA capability at an affordable price but also the capability of expansion at minimum cost. Each of the RASCARS can be installed as a stand alone radar ARPA system or can form part of an Integrated Bridge Systems. Future enhancements can be accommodated quickly and inexpensively because of this flexible design concept.



Raster Scan Display

Conventional radar and ARPA information is displayed on a high resolution raster scan display. Like a TV set the display is constant and bright and can be viewed easily without the use of a hood. Two display sizes are included in the RASCAR series: 25-inch and 19-inch diagonal displaying a 340mm and 250mm radar PPI respectively. The 19-inch diagonal display is available in color or monochrome. The 25-inch diagonal display is currently available in monochrome only but is designed to drive a color display when these become economically available.

The RASCAR 3400M Has a 25-inch diagonal green monochrome display fulfilling all IMO requirements for a 340mm effective-diameter radar display and a 16-inch ARPA

The RASCAR 2500C is a 19-inch diagonal color display fulfilling the IMO requirements for a 250mm effective-diameter radar. The integral ARPA, while not required by law in this size of radar, more than satisfies the mandated requirements for a "plotting facility" and gives the operator the added convenience and safety of full ARPA capability without cost penalties.

The RASCAR 2500M identical to the RASCAR 2500C but with a green monochrome presentation.

Each display console can be viewed and operated by a seated or standing operator.

TOUCH SCREEN CONTROLS

All other radar/ARPA systems today present the operator with a complex control layout. Even with careful planning and ingenuity, it is a cluttered and complex man/machine interface. Several years ago Sperry made major steps forward in its CAS program by logically grouping the control functions of its ARPAs into pages. Soft mechanical switches, located around the data display, had multiple functions depending on which page was called up and displayed. We have now carried this page approach a giant step forward.

All radar and ARPA functions are now controlled by the Touch Screen directly over the PPI display. No longer does the operator locate the cursor on a radar target by moving remotely located controls. Simply by touching the screen in the desired location a target can be acquired or cancelled, a range and bearing can be measured or target ship data can be reviewed *immediately*. The human operator is now *directly* in control of the display, "doing what comes naturally!!"

How Does it Work?

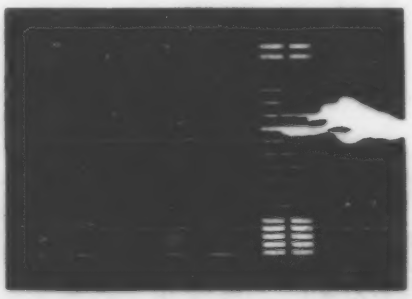
The Touch Screen is an extremely robust device that senses the position of the human finger on the screen. Associated software interprets the touch as an indication of position or the operation of a "switch" or "control" and responds rapidly and clearly. Non conductive material such as a cleaning rag will not activate the screen. The software even allows you to make extremely precise locations of the Variable Range Marker and Electronic Bearing Line independent of the size of the operator's finger.

How Reliable is it?

The Touch Screen is a capacitive device made of tough glass. The surface is durably coated with a sensitive material (not a matrix of fine, delicate wires). The surface cannot be damaged by accidentally dropping sharp objects on it. It is impervious to the effects of moisture or salt corrosion. It therefore avoids the reliability problems of mechanical switches and potentiometers.

Is it Expensive?

The Touch Screen approach actually costs less to incorporate than the 60 or more discreet mechanical controls used in previous generations. This is one of the reasons we can offer the highest specifications and features, without the hidden costs of "options" at a "no nonsense" competitive price



Sperry makes the difference.

The Product Benefit:

Based firmly on Sperry's traditional high standard of quality, the GPS Core Module is designed to provide you with a valuable investment for many years. And it will have the full backing of Sperry's unequaled worldwide support organization.

The many benefits to be derived from Sperry's products include economies in time and money. And, Sperry systems are flexible, linking easily into modern ship system networks.

The Family:

Sperry products are conceived and designed with a strong emphasis on common engineering standards, and on ergonomics and aesthetics.

Whether you're installing a single unit or fully integrated ship, each sub-system reflects this family approach.

Sperry's objective is to enable you to configure your requirements flexibly without any loss in ergonomics or aesthetics, and to lower your support costs through these common engineering standards.

The Total Supplier:

With a world-leading capability in navigation, electronic data processing and communications, Sperry wants to help you configure and specify all your marine requirements.

By considering an integrated approach from the outset, you will derive many additional benefits of compatibility and commonality, leading to greater flexibility and more profitable operations.

Sperry wants to be your sole contractor to help you meet these objectives. We can show you that doing business with Sperry makes a difference.

FOR FURTHER INFORMATION ON THIS AND OTHER MARINE NAVIGATION AND CONTROL PRODUCTS CONTACT:

SPERRY CORPORATION
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Charlottesville, Virginia 22906
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OVER 250 MARINE SALES & SERVICE LOCATIONS
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Printed in U.S.A. JA-60-23-4780-10K

RASTERSCAN RADAR/ARPA

RASCAR Series

PRELIMINARY TECHNICAL SPECIFICATIONS

(The specifications in this paper may vary from those of the supplied equipment due to Sperry's policy of continual product improvement.)

DESCRIPTION

A series of commercial marine rasterscan radar systems with integral ARPA, azimuth stabilization and True Motion features.

ANTENNAE

A series of end fed, slotted waveguide antennae with digital antenna position data format. The Circular Polarized (CP) antenna has switchable, back-to-back, horizontally and circularily polarized elements. Each antenna is fitted with a 100/220 VAC motor. The supply voltage is selectable on installation.

Rotation speed is 22 rpm (nominal) in relative wind speeds of 100 knots or less.

Nominal Size	Beamwidths (-3dB)		Sidelobe Suppression
	Horiz	Vert	
X-Band			
7 ft	1.0	21	-27 dB within ±10 deg
9 ft	0.8	21	-30 dB outside ±10 deg
9 ft (CP)	0.8	22	
S-Band			
14 ft	1.8	25	

TRANSMITTERS

	Nominal Peak Power	Frequency
X-Band	25 KW	9410 ±30 MHz
X-Band	50 KW	9375 ±30 MHz
S-Band	30 KW	3050 ±25 MHz
S-Band	60 KW	3050 ±25 MHz

TRANSMITTERS (continued)

Pulse Lengths/Pulse Repetition Rates

Range Scales	Pulse Length	Pulse Rep Rate
0.25 to 1.5 nmi	0.07 usec	3200 pps
3 nmi	0.25 usec	1600 pps
6 to 12 nmi	0.4 usec	1600 pps
24 to 96 nmi	1.0 usec	640 pps

Power pulse feature increases pulse length to next longest in all lower range scales through 12 nmi.

RECEIVER

Low noise type with Microwave Integrated Circuit (MIC). Logarithmic amplifier. Automatic fine tuning with manual override.

Intermediate Frequency	60 MHz
I.F. Bandwidth	17 MHz
Noise Figure	
X-Band	better than 6.0 dB
S-Band	better than 6.0 dB

PERFORMANCE MONITOR (optional)

Active type with indication of normal, 2 and 4 dB deterioration of transmitter performance and normal, 3 and 6 dB deterioration of receiver performance. Passive type also available.

DISPLAYS

Free standing, rasterscan type, capable of modular integration to form multi-display console.

RASCAR 3400M	Monochrome Rasterscan daylight viewable display with effective diameter of 340 mm.
RASCAR 2500C	Color Rasterscan daylight viewable display with effective diameter of 250 mm.
RASCAR 2500M	Monochrome Rasterscan daylight viewable display with effective diameter of 250 mm.
RASCAR 2500S	Monochrome daylight viewable slave monitor with effective diameter of 250 mm.

Display Resolution	1280 H x 1024 V
Refresh Rate	Greater than 50 Hz non-interlaced
Man/Machine Interface	Control functions are executed through touch screen

DISPLAYS (continued)

Radar Functions

Standby/On	With "ready" indication
Electronic Bearing Line (EBL)	"Free-footed." EBL origin can be set anywhere within effective radar display area. Bearing accuracy - 1 degree Four digit display in degrees and tenths.
Variable Range Marker (VRM)	Cross hair or dashed circle on EBL. Range 0 to 96 nmi. Accuracy 1.5 percent or 50 meters. Four-digit readout showing nmi, tenths and hundredths.
Range Scale Selection	Present range scale and ring separation displayed in nmi.

Fixed Range Rings

Range Scale	No. of Rings	Separation
0.25 nmi	5	0.05 nmi
0.5 nmi	5	0.1 nmi
0.75 nmi	6	0.25 nmi
1.5 nmi	6	0.25 nmi
3.0 nmi	6	0.5 nmi
6.0 nmi	6	1.0 nmi
12.0 nmi	6	2.0 nmi
24.0 nmi	6	4.0 nmi
36.0 nmi	6	6.0 nmi
48.0 nmi	6	8.0 nmi
96.0 nmi	6	16.0 nmi

Range ring accuracy - 1.5 percent of range scale or 50 meter whichever is greater.

Ownship Heading/ Speed Displays	Three digit displays in degrees, and knots and tenths of knots
Fixed Bearing Ring	360 degrees with one degree graduations

DISPLAYS (continued)

Power Pulse	Momentary switch selecting next largest pulse length in lower range scales including 12 nmi
Circular Polarized Antenna Select (optional)	
Performance Monitor On/Off (optional)	Active or passive type
Tune	Operator selectable auto or manual with bar graph indication
Gain FTC STC	With bar graph indication
Heading Mark	Solid line from sweep center to fixed bearing ring marking position on ship's head. Momentary "Off" switch.
Stern Flasher (option)	Dotted line from sweep center to fixed bearing ring marking position of ship's stern. Extinguished by Heading Mark momentary switch
Off Centering	Ownship position can be placed up to 0.7 of radius from radar display area center in any direction
Radar Interference Canceller	Selectable on installation 2 of 3 or 3 of 3
Auto Anti-Clutter	When auto anti-clutter is selected STC control is inoperative

DISPLAYS (continued)

Display Orientations Head-Up (unstablized) North-Up (stablized) Course-Up (stablized)	Azimuth stabilizer will accommodate following formats: 360x synchro 20-90 V L-L 20-115 VAC 50/60 Hz reference 1/6th degree step 20-70 VDC or half wave rectified 180x synchro 90 V L-L 100/110 V 50/60 Hz reference 90x synchro 90 V L-L 100/110 V 50/60 Hz reference Azimuth stabilizer maintains heading when the radar system power is turned off
True/Relative Motion Indicator	

TRUE MOTION FUNCTIONS

Automatic reset	Ownship's position, on reaching a distance of 0.7 of radius from radar display area center, sounds alarm and returns to previously entered true motion start position
Manual/Log Speed Selection	
Speed Log Input Formats	Will accommodate following formats: Single axis - pulse or contact closure. 200 pulses per nmi Optional serial data - to customer's specifications
Manual Set and Drift	Auto set and drift available if using dual axis bottom lock log or the NAVMARKs feature of the NAVLINEs option.
Accuracy	Speed - better than 3.5 percent Course - better than +3 degrees

ARPA FUNCTIONS

ARPA is the standard in all RASCARs. Enhanced ARPA is optional and items marked with * indicate features of the Enhanced ARPA where different.

Tracker capacity 20 targets * 40 targets

Tracking Range

In Range Scale	Tracking Range
0.25-1.5	18 NMI
3-12	36 NMI
24-96	72 NMI

Manual Acquisition — By means of Target Indication Cursor and touchscreen

Guard Ring Intruder — Either guard ring, when enabled, will alert visually and audibly when crossed by non-tracked target. Operator may acknowledge and acquire or merely acknowledge

Guard Ring Auto Acquisition — When enabled, each intruder is automatically acquired to maximum capacity of the tracker

*Area Acquisition — When enabled, automatic acquisition of all targets (up to maximum capacity of the tracker) entering within 36 miles of ownship. Operator may define exclusion zones

Vector/PADS Selection

Vectors — Selectable true or relative with length adjustable from 0 to 60 minutes in steps of one minute

Predicated Areas of Danger (PADs) — Predicted Areas of Danger graphically displayed based on CPA and TCPA limits selected by operator

Trial Maneuver — When selected permits operator to enter trial values of ownship's course or speed or both and observe effects on targets' data, vectors or PADs

ARPA FUNCTIONS (continued)

History Dots	When enabled generates up to five dots astern of each tracked target indicated the targets past true position at intervals adjustable from 1 to 12 minutes in one minute steps
Data Readout	Selection of a tracked target by its track number will display: • target's range • target's bearing • target's true course and speed • target's CPA and TCPA
Alarm Data	Audible and visual alarms of: • Guard ring intruder (if enabled) • Target threat • Lost target • Track file full • System malfunctions
Tracking Conditions	Operator may optimize tracking conditions by selecting: • Harbor or sea mode • High or low clutter mode

BITE FUNCTIONS System failures to the smallest replaceable module level are indicated visually and/or audibly and identified.

SPERRY CORPORATION
AEROSPACE & MARINE GROUP
CHARLOTTESVILLE, VA 22906

APPENDIX C

NAVIGATION EQUIPMENT

DOBROCKY SEATECH LTD.

LORAN-C DRIFTING BUOYS

DOBROCKY SEATECH LTD. LORAN-C
DRIFTING BUOYS

The purpose of the buoy is to establish patterns of circulation, trajectories of water parcels and pollutants. Briefty, the drifting buoy is coupled with a drogue which is designed to faithfully follow a water parcel. The buoy is equipped with a Loran-C receiver and a VHF transmitter. At preselected intervals (typically 30 minutes) the buoy transmits its position and records it in on-board memory. The transmission range is at least 100 km and the internal memory can record about two months of fixes at a 30 minute sampling interval.

In surveys undertaken to date, up to six buoys without internal data storage have been operated concurrently over a 5,000 square kilometre area. Data were received on board an attending vessel, recorded on a printer and logged on a microcomputer. Although it was not necessary for the attending vessel to remain within 100 km of the drifting buoy to relocate it, data were lost when radio contact was broken. The internal memory obviates the need for constant tending. The buoys may be revisited every few days if desireable but full data recovery is possible over a period of up to two months.

The superiority of the Dobrocky Seatech Ltd. Loran-C Drifting Buoy over satellite tracked buoys is two-fold:

The data are superior. They are equally spaced in time with fix precisions of 0.1 μs in time delays or about 30 metres in position. The fine temporal and geographic resolution permits quantification of current features two orders of magnitude smaller than possible with satellite tracked buoys.

The buoys are designed to be recovered and re-used thus significantly reducing costs.

To date we have found that the superior resolution of the Loran-C buoy data has enabled us to compute semi-duirnal tidal ellipses (from the time derivative of the position data). Also to date, not one buoy has been lost.

DOBROCKY SEATECH LTD. LORAN-C

DRIFTING BUOY SPECIFICATIONS

Hull

for deployments up to three months:

ellipsoidal fiberglass	4 f diameter x 1.5 f deep
weight w/batteries	approx. 160 lbs.

for deployments less than 20 days:

light bulb shaped fiberglass	2 f long x 1.5 f max. diameter
weight w/batteries	approx. 50 lbs.

Loran-C

Sensitivity	1 microvolt/m
Dynamic Range	105 dB
Resolution	0.1 microseconds
Chain Selection	Manual for world-wide GRI's
Slave Acquisition	Automatic for GRI selected

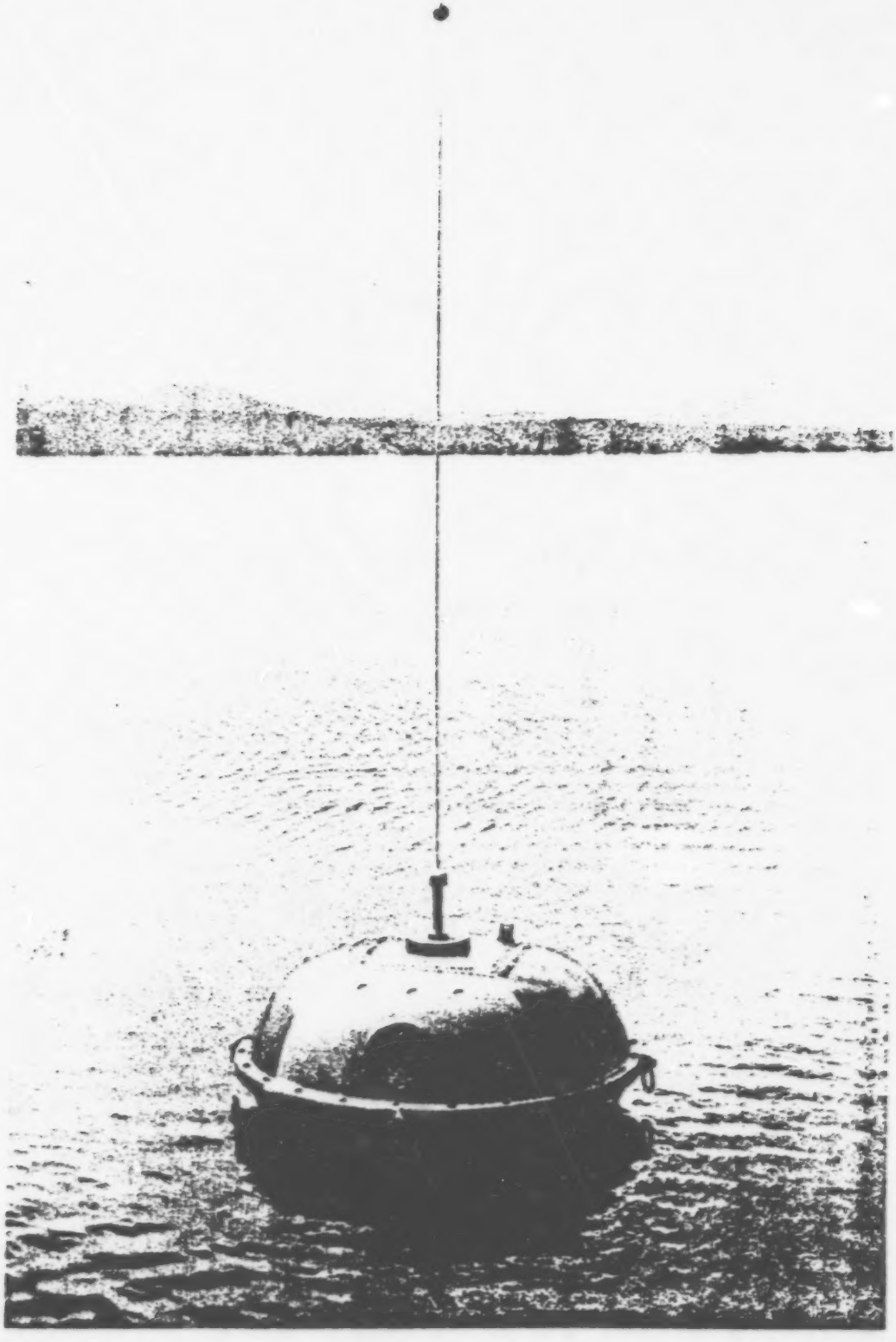
VHF Radio Transmitter

R.F. Power Output	75 watts maximum
Spurious and Harmonic Emissions	approx. -70 dB

Controller/Memory

Transmit Interval	Selectable in 10 minutes increments to 100 minutes
Data Message Repetition	Selectable 1 to 10 times per transmission

Buoy I.D. No.	Selectable 0 to 99
Memory Capacity	32 to 64 k bytes in 8 k byte increments. Standard 32 k byte memory sufficient for about two month's data at half-hourly sampling.



Dobrocky
SEATECH

LORAN-C RECEIVER

RAYNAV 750 S/D

LORAN-C RECEIVER

The recommended LORAN-C receiver (brochure not available) RAYNAV 750 S/D, has the following additional functions to the RAYNAV 750 MKII

a. Automatic generation of search patterns

b. Differential LORAN-C operations.

RAYNAV-750 MKII...
every imaginable feature...made easy to use.

RAYNAV 750

Navigate into the 21st century with the most advanced Loran-C receiver and a specially programmed computer combined in one very small unit.

RAYNAV-750 MKII

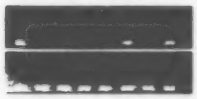
New
- Automatic waypoint sequencing. Selects next waypoint "going" and "coming"

New
- Automatic Magnetic Variation. Compensates true bearing data to magnetic bearing.

New
- Automatic ASF. Improves correlation between electronic data and navigation charts

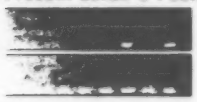
New
- Additional navigation calculations: Velocity Towards Destination (VTD), Velocity Along Route (VAR), Course Made Good (CMG).
- Programmed for most Loran-C GRIs in the world. GRIs of station last used operate at turn-on.
- Position automatically calculated and displayed at turn-on.
- All secondary stations automatically tracked, your position immediately verifiable.
- Store up to 50 waypoints.
- Distance, bearing and Time-To-Go to next waypoint automatically displayed. A warning alerts you to approaching waypoints and indicates arrival.
- Automatic self test. Readout of signal-to-noise ratio (SNR) verifies performance.
- Six automatic notch filters.
- Sounds alarm if steering error exceeds pre-set limits.
- Numerical steering guide shows you how far to steer right or left.
- Large, back lit LCD readouts.
- Adjustable anchor watch sounds an alarm if vessel strays as little as 1/100 nm.
- Autopilot output: NMEA 0180 Std.
- All crucial data stored even when the unit is turned off. Just push PWR, and RAYNAV-750 MKII begins acquiring and tracking Loran-C signals. Here are some typical operating sequences.

Loran-C Station in Use



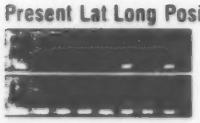
Select: STN
Upper readout shows GRI and selected secondaries used for latitude/longitude conversions. Lower readout shows that 1, 2, and 5 secondaries are being tracked.

Present Loran-C Position



Select: TD
Upper and lower readouts show TDs (Loran-C LOPs) of secondaries 1 and 2.

Present Lat Long Position

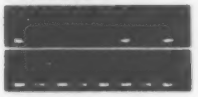


Select: L L
Upper and lower readouts show latitude and longitude.

Checking Loran-C Signals

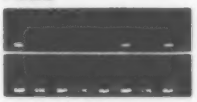
Select: SNR (Signal-to-Noise Ratio)
The upper readout shows the tracking status of the master and secondary stations by number sequence: 0 & 1 searching, 2, 3, & 4 settling, 5, 6, & 7 cycle matching, 8 locked on (maximum accuracy achieved), and 9 weak signal tracking. The lower readout shows the Signal-to-Noise Ratios of the master and two secondaries on a scale of 100. Anything over 15 indicates an adequate signal.

Course, Speed, and Velocity Towards Destination



Select: L L
Press: CMG
Upper readout shows velocity "present" component of ship's Speed Towards Destination. Lower readout shows present true course and Speed Over Ground.

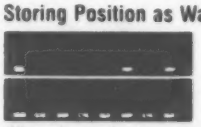
Course Made Good and Velocity Along Route



Select: L L
Press: CMG, CMG

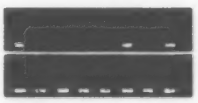
Top, left readout shows Course Made Good (CMG) – the measured direction from vessel's start point relative to "true" or magnetic North. Top, right readout shows vessel's Velocity Along Route (eg.

Storing Position as Waypoint



A present position (either as TDs or as Lat Long coordinates) is easily stored as a waypoint or destination. When the readouts show the desired position:

Press: ● and assigned numerical designation: 1, 0



Press: ▬

The desired position is frozen so that it may be recorded with its assigned number (25).

Press: ▬

The desired position is now recorded as waypoint 25. Readouts automatically return to latest updated coordinates. In addition to automatic recording of a present position, other waypoints may be entered by the keyboard.

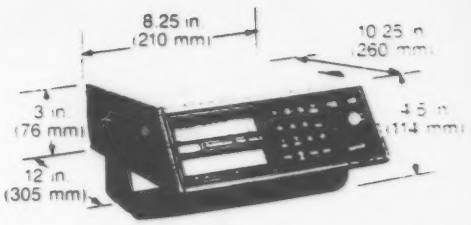
Proceeding to Waypoint

Select: APT
Press: 1, 0, ▢, ▢, ▢, APT

The upper readout shows waypoint, hours, and minutes to go. Lower readout shows bearing and distance from present position to waypoint.

Steering to Waypoint

Select: XTE
Upper readout indicates present position starting point (0.0) and destination (waypoint 25). Lower readout indicates on course (.00 in center). A 0.25 at left would indicate ¼ mile off course to port. A 0.50 at right indicates ½ mile off course to starboard.



Easy installation

Weighing 8.9 lbs. (4 kg) in a rugged splash-proof case, the RAYNAV-750 MKII can be installed just about anywhere.

The antenna coupler, which is 9.4 in. (240 mm) long and 2.2 in. (56 mm) in diameter, weighs 2.4 lbs. (1.1 kg). It can be mounted as far away as 200 ft. (61m) for optimum performance clear of metal structures. The antenna coupler is designed to be used with a standard 96 or 108-inch (2.4-2.7m) whip antenna. Special swivel and extension mounts are available as options.

Specifications

Receiver Sensitivity: 1.0 Microvolts
Dynamic Range: 110 dB
Tracking: Up to 4 master secondary pairs simultaneously
Signal Monitoring: Signal-to-Noise Ratios (SNRs) of master and secondaries continually monitored with provision for visual readout
Acquisition Time: Normal conditions 1-3 minutes. Cycle-matching, 3rd cycle automatically, 4-7th cycles manually
Warning Indicators: Visual indicators for loss of 3rd cycle matching, unusable SNR, manual cycle selection, and station malfunction
RF Interference Suppression: 6 automatically adjusted notch filters
Antenna: 96-108 inch whip (not supplied)
Remote Antenna Coupler: Self-contained with pre-amp, supplied as standard equipment
Operating Voltage: 10 to 45 Vdc
Power Consumption: 18 watts

Unique color plotter and data recorder options

The new Raytheon MVP-51 Color Video Plotter, when used with the RAYNAV-750 MKII, provides a [illegible] Lat Long track [illegible] as well as waypoints, position, course, speed, and other [illegible] The plotter's [illegible] can also be [illegible] The plotter has a 5½ inch [illegible] CRT and the Raytheon Data Recorder and MVP-51 can also be stored on cassette tape for [illegible]

Unmatched 2-year warranty

All Raytheon Marine Company equipment has a [illegible] warranty, and all equipment, with the exception of [illegible] within 30 miles of any of our convenient [illegible] U.S. dealers and authorized service [illegible] factory-authorized service [illegible] For [illegible] the [illegible] dealer to contact us [illegible]

RAYTHEON

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